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THE VISCOSITY AND FLUIDITY OF AQUEOUS POTASSIUM FERROCYANIDE SOLUTIONS[1]

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The viscosity of aqueous electrolyte solutions is occupying considerable attention at the present time. The empirical equation put forward by Jones and Dole (1) relating the relative fluidity $\varphi = \varphi_c/\varphi_o$, to the square root of the concentration, c, (in mols per liter):

$$\varphi = 1 - A\sqrt{c} + B.c + \ldots \quad (1)$$

has been theoretically derived from considerations of the Debye-Hückel theory (2) as:

$$\eta = \frac{\eta_c}{\eta_o} = 1 + A\sqrt{c} + \ldots \quad (2)$$

and the Falkenhagen constant A for a dozen electrolytes has been evaluated experimentally through numerous recent measurements (3) and the interpretation of some earlier viscosity data (4).

Theoretically, the value of A must be positive for electrolytes, and zero for non-electrolytes. Experimental verification of the equation is given in Table I.

In the course of some investigations in progress in this laboratory, we found occasion to measure the viscosities of dilute aqueous solutions of potassium ferrocyanide with sufficient accuracy to warrant interpretation of our results in the light of the interionic attraction theory as a test of the Falkenhagen equation when applied to an electrolyte of the uni-tetravalent type.

[1]Contribution from the Chemical Laboratory of Miami University, Oxford, Ohio.

EXPERIMENTAL

Apparatus.—The viscometer was of the Bingham variable-pressure type, constructed of Pyrex glass. Details of the apparatus are elsewhere described (3d, 7); it may be noted here that the pressures used ranged between 110 and 125 cm. of water, the pressures being estimated to the nearest 0.01 cm.;

TABLE I

COMPARISON OF THEORETICAL AND EXPERIMENTAL VALUES OF A IN EQ. (1)

Solute	Temp.	A (Theory)	A (Found)	Reference
NH_4Cl	25°	0.0050	0.0057	3 f
LiCl*	25°	0.0237	0.0240	6
KCl	18°	0.0049	0.0052	3 a, b
KCl	25°	0.0050	0.0052	3 f, g
KCl	35°	0.0052	0.0051	3 b
KBr	25°	0.0049	0.0047	3 g
$KClO_3$	18°	0.0051	0.0028	3 d
$KClO_3$	18°	0.0051	0.0050	3 b
$KClO_3$	25°	0.0054	0.0050	3 f
$KClO_3$	35°	0.0058	0.0049	3 b
$KBrO_3$	25°	0.0058	0.0058	3 f
$LiIO_3$	18°	0.0094	0.0108	4 c
HNO_3	18°	0.0021	0.0021	3 b
HNO_3	35°	0.0025	0.0023	3 b
$LiNO_3$	18°	0.0069	0.0082	4 a
KNO_3	25°	0.0052	0.0050	3 f
$RbNO_3$	18°	0.0049	0.0070	3 c
$RbNO_3$	18°	0.0049	0.0050	3 b
$RbNO_3$	25°	0.0051	0.0040	3 c
$RbNO_3$	35°	0.0054	0.0056	3 b
$CsNO_3$	18°	0.0048	0.0103	4 b
$CsNO_3$	25°	0.0050	0.0043	3 f
$BaCl_2$	18°	0.0145	0.0140	3 e
$BaCl_2$	25°	0.0147	0.0201	1
Sucrose	25°	0	0	3 f
Urea	18°	0	0	5
Urea	25°	0	0	3 f, 5

*NOTE: In acetone.

the times of flow ranged between 1,325 and 1,925 seconds, the times being read to the nearest 0.1 second; while temperatures were read to 0.001° and the bath surrounding the instrument was controlled to ± 0.003° C. with a Beckmann thermometer. The probable error of a determination of relative viscosity as the average of a pair of observations (from 5 determinations of the viscosity of water at 18° involving 13 observations)

obtained with the instrument by one of us, was computed by the method of least squares as 0.008 percent. Much practice is needful in attaining this precision, just as it is in other skills which depend upon exact co-ordination of hand and eye; and the mean error of the measurements carried out by the junior author and herein recorded amounts to 0.03 percent.

Materials.—Solvent: Ordinarily distilled water was redistilled from alkaline permanganate, and then distilled very slowly for a third time.

Solute: The potassium ferrocyanide was "Coleman and Bell's" C. P. quality, used as received.

Solutions were not optically clear, i. e., they showed some Tyndall effect when held in a strong light after vigorous shaking; but upon allowing the solutions to stand, and then drawing off samples for filling the viscometer from the upper level of liquid, stoppage of the capillary by dust particles was obviated.

Solutions.—Moderately concentrated solutions were made up by weight, and the concentrations in weight-percent were calculated to concentrations in mols per liter by means of tables of density. The more dilute solutions were made by measuring additional water into a measured volume of a more concentrated solution.

Densities.—Densities were interpolated from the International Critical Tables, (III, 92), as being of sufficient accuracy for the conversion of our moderately dilute solutions from a weight-percent basis to a mol-volume basis; and of more than sufficient accuracy for their use in viscosity measurement. Since our instrument is of the variable-pressure type, the density of the liquid enters only into a hydrostatic head correction (amounting to less than 0.1 percent of the total pressure) and into a kinetic energy correction (amounting to between 0.3 and 0.4 percent of the total pressure); an error in density of 3 percent will affect the precision of the viscosity measurements only 1 :10,000.

Data.—The experimental results are summarized in Table II. Three measurements of the viscosity of aqueous potassium ferrocyanide at 25° C. by Rankin and Taylor (8) are included for comparison.

TABLE II

SUMMARY OF EXPERIMENTAL DATA ON THE VISCOSITY AND FLUIDITY OF POTASSIUM FERROCYANIDE

No. of Runs	Conc. c	Density ρ	Viscosity η	$(\eta-1)/c$	$\sqrt{c}$	Fluidity φ	$(\varphi-1)/\sqrt{c}$	φ Calc. by Eq.	$\triangle$ φobs.$-\varphi$ calc.	
					18°					
2	0.2334	1.0536	1.09385	0.402	0.4831	0.9142	—0.1776	0.9136	0.0006	
4	0.1556	1.0350	1.0615	0.395	0.3945	0.9421	—0.1469	0.9406	0.0015	
3	0.0934	1.0203	1.0399	0.427	0.3056	0.9616	—0.12555	0.9627	—0.0011	
2	0.0424	1.0085	1.0197	0.465	0.2059	0.9807	—0.0938	0.9814	—0.0007	
2	0.0222	1.0038	1.0112	0.5045	0.1490	0.9889	—0.0744	0.9893	—0.0004	
2	0.0111	1.0012	1.0063	0.568	0.1054	0.9937	—0.0594	0.9939	—0.0002	
2	0.0028	0.9992	1.0019	0.679	0.0529	0.9981	—0.0358	0.9978	0.0003	
7	0	0.9986	1.0000	.....	0	1.0000	.....	1.0000	0	$\Sigma \triangle i=0.0000$
										$\frac{\Sigma \mid \triangle i \mid}{N}=0.0007$
					25°					
	(0.5000)	.....	(1.2575)	(0.515)	(0.7071)	(0.79525)	(—0.2896)	0.7967	(—0.0014)	
	(0.2500)	.....	(1.1173)	(0.469)	(0.5000)	(0.8950)	(—0.2100)	0.8948	(0.0002)	
3	0.2327	1.0515	1.1079	0.464	0.4824	0.9026	—0.2019	0.9017	0.0009	
3	0.1551	1.0332	1.0714	0.460	0.3938	0.9334	—0.1692	0.9327	0.0007	
	(0.1250)	.....	(1.9593)	(0.474)	(0.3536)	(0.9440)	(—0.1583)	0.9448	(—0.0008)	
3	0.0931	1.0187	1.0431	0.484	0.3051	0.95685	—0.1414	0.9579	—0.0010	
2	0.0423	1.0070	1.0232	0.5485	0.2057	0.9773	—0.1102	0.9792	—0.0019	
3	0.0222	1.0022	1.0120	0.5405	0.1490	0.9881	—0.0796	0.9881	0	
3	0.0111	0.9996	1.00635	0.572	0.1054	0.9937	—0.0599	0.9933	0.0004	
2	0.0055	0.9983	1.0033	0.600	0.0742	0.9967	—0.0444	0.9962	0.0005	
3	0.0028	0.9976	1.0018	0.642	0.0529	0.9982	—0.0340	0.9977	0.0005	
8	0	0.9970	1.0000	.....	0	1.0000	.....	1.0000	0	$\Sigma \triangle i=0.0001$
										$\frac{\Sigma \mid \triangle i \mid}{N}=0.0007$

NOTE: Bracketed values are taken from Rankin and Taylor for comparison.

INTERPRETATION OF RESULTS

When the values of $(\eta-1)/c$ were plotted as ordinates against the corresponding values of c as abscissas, (or preferably against the corresponding values of $\sqrt{c}$, since this effects a spreading of the points at low concentration) concave sagged curves were obtained which exhibited minima at about 0.18 mol per liter ($\sqrt{c} = 0.43$). While $(\eta-1)/c$ is strictly the slope of the chord connecting a point on the viscosity—concentration curve with the origin, it approximates the slope of the curve at that point; thus the initial downward slope of these curves corresponds to negative curvature in the $\eta-c$ curves, and the minimum to a point of inflection in the latter. These plots of the "Grüneisen function" emphasize that the negative curvature of the $\eta-c$ curve is more pronounced at the lower temperature; in accord with the expected behavior of electrolytes in aqueous solution (4a).

TABLE III

THE FLUIDITY AND VISCOSITY OF AQUEOUS POTASSIUM FERROCYANIDE

Concentration mols per liter	18°		25°	
	φ	η	φ	η
0.001	0.9989	1.0011	0.9989	1.0011
0.0025	0.9980	1.0020	0.9978	1.0022
0.005	0.9967	1.0033	0.9964	1.0036
0.01	0.9944	1.0056	0.9938	1.0062
0.025	0.9882	1.0119	0.9868	1.0134
0.05	0.9786	1.0219	0.9759	1.0247
0.1	0.9604	1.0412	0.9550	1.0471
0.25	0.9081	1.1012	0.8948	1.1176

When the values of $(\varphi - 1)/\sqrt{c}$ were plotted as ordinates against the corresponding values of $\sqrt{c}$ as abscissas, the points lay approximately along straight lines which intersected the axis of $(\varphi - 1)/\sqrt{c}$ at -0.0245. The equations of these lines were established as:

$$(\varphi - 1)/\sqrt{c} = -0.0245 - 0.3185\sqrt{c} \text{ at } 18° \text{ C.}$$
$$(\varphi - 1)/\sqrt{c} = -0.0245 - 0.3720\sqrt{c} \text{ at } 25° \text{ C.}$$

whence:

$$\varphi = 1 - 0.0245\sqrt{c} - 0.3185\,c \text{ at } 18° \text{ C.} \quad (3)$$
$$\varphi = 1 - 0.0245\sqrt{c} - 0.3720\,c \text{ at } 25° \text{ C.} \quad (4)$$

The fluidities calculated by these equations, and the deviations from the observed fluidities, are given in Table II.

The relative viscosities and fluidities of aqueous potassium ferrocyanide at round concentrations, as calculated by means of Eqs. (3) and (4), are given in Table III.

SUMMARY AND CONCLUSION

Measurements have been made on the relative viscosity of aqueous solutions of potassium ferrocyanide at 18° and 25° C. over the range of 0.003 to 0.223 mol per liter. Our values at 25° C. accord well with some earlier values recorded in the literature.

The stiffening effect on the solution due to the electric forces of the ions in tending to maintain a space-lattice structure has been observed. While the data necessary for the computation of the constant A by means of the equation of Falkenhagen and Vernon (2e) are not available to us, and we have not found in the literature any computation of this constant for $K_4Fe(CN)_6$; the observed value : $A = 0.0245$, compares favorably in order of magnitude with the value to be expected.

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GEOGRAPHY AND GEOLOGY OF KELLEY'S ISLAND

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HISTORY

After the turn of the nineteenth century, a few whites began to visit Kelley's Island for the purpose of trading, but at the outbreak of the war of 1812, they were driven away by the menacing attitude of the hostile Indians. General Harrison, then commanding the Army of the Northwest, stationed a guard on the west shore for the purpose of reconnoitering the movements of the British and Indians on the lake. The squadron of Commodore Perry lay for a time in the harbor south of the island, prior to its history-making engagement with the British north of Put-in-Bay. The successful outcome of the Battle of Lake Erie forced the Indians to flee the Island region. "Cunningham's Island," as it was originally known, after its first white trader (1803), did not become permanently settled until after 1833, when Irad and Datus Kelley acquired title to the whole island. For a hundred years, it has been called Kelley's Island.

Evidences of former Indian occupation are numerous. There are remains of earthworks on the Huntington property, inclosing an area of nearly seven acres. Most noted of all is Inscription Rock, which formerly bore deeply engraved pictographs on its glacially-smoothed surface. The wear of sightseers feet and the zeal of initial carvers has for the last decade rendered the inscriptions illegible. Inscription Rock measures approximately thirty feet long, twenty-one feet wide, stands ten feet above the water and is located at the water's edge of the south shore near Lay Bros. dock, where it has been separated by wave action from the main island mass of Columbus limestone. This famous Indian relic was discovered by Charles Olmstead, of Connecticut, in the year 1833, while on the island studying the glacial grooves. Its symbols were later authoritatively interpreted as depicting the occupation of this region by the Eries, the coming of the Wyandots, the final triumph of the Iroquois, and the flight of the Eries, who gave the lake its name.

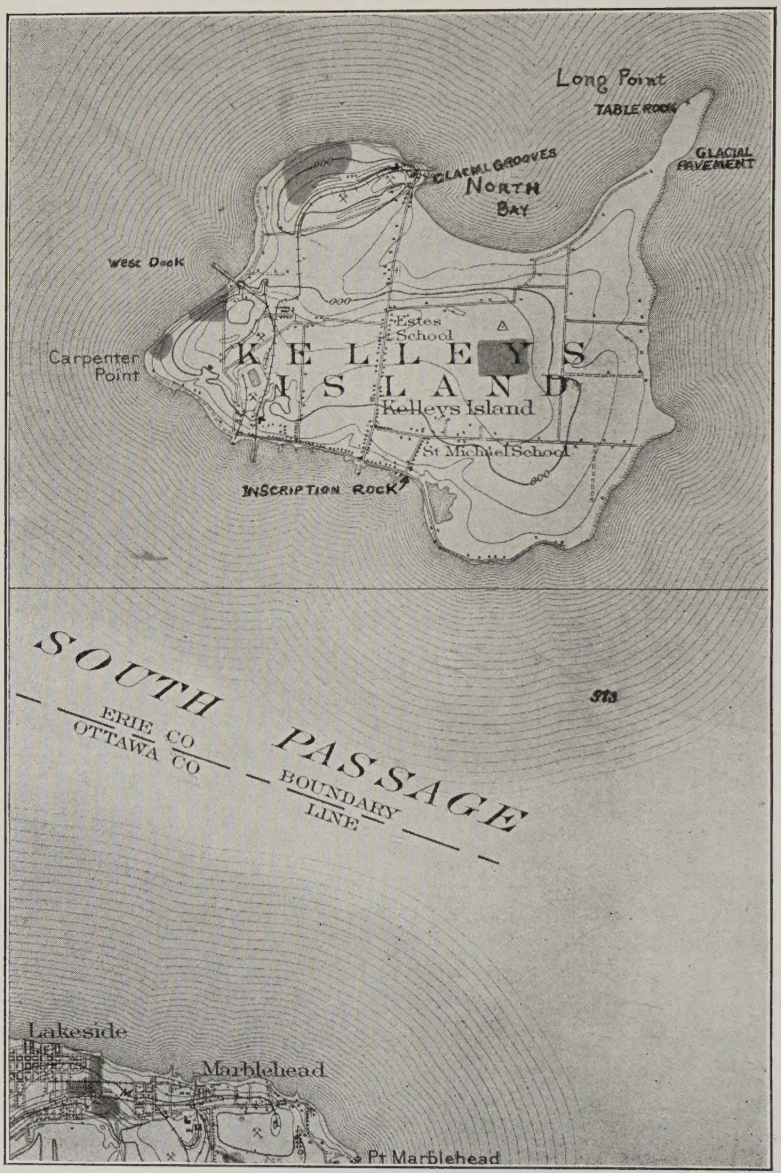

FIG. 1. Map of Kelley's Island

GENERAL DISCUSSION

This picturesque island lies three and one-half miles off the mainland of Marblehead on the Ottawa peninsula and nine miles directly north of the city of Sandusky. It is second in size to Pelee Island and the largest of the islands in Lake Erie, belonging to the United States. The island is widely known for its extensive limestone quarries and the glacial grooves on the promontory near the west shore of North Bay.

In outline, Kelley's Island may be readily described as possessing a marked resemblance to the continent of Australia (Fig. 1). Eighteen miles of predominantly rocky shoreline surrounds the twenty-eight hundred and eighty-eight acres of the island. A cobble-stone beach is characteristic but numerous other types of shoreline lend variety and beauty.

The west shore, and the south shore as far east as Inscription Rock, is a cliff generally six to seven feet high, fronted by a beach made up of limestone cobbles of various sizes. Nor far east of Inscription Rock there is a good example of a bay-mouth bar, on the crest of which the south shore road has been constructed. From this point eastward and along the east shore to within half a mile of the end of Long Point, the beach is composed of limestone cobbles with occasionally a few erratics; from this beach the island rises gently to the interior. The remaining portion of the east shore of Long Point is rocky, but without high cliffs or loose stone.

The east slope of Kelley's Island is a gradual rise from Lake Erie, the result of exposure to the full force of the southwestward moving ice mass, whereas, the lee slopes not exposed to the ice action are bordered by bold cliffs. The best illustration of this process is that of Long Point. The west shore is an almost continuous line of cliffs ten feet in height that have been protected from much of the direct force of the ice and increased in sharpness by the breaking off of huge blocks by weathering and wave action along the joints. The main joints trend N. 30° E. and are generally parallel to the shore. Table Rock is an example of a moderately sized block that has been separated from the mainland by wave erosion along joints; it has been undermined by wave action to such an extent that it is almost ready to topple into the lake.

The shore of North Bay, from a point south of the "L" in "Long Point" to the North Side quarry docks, is a stretch

approximately a mile in length, of the only sand beach on the island, except for a short stretch north of the West stone-loading dock. The northwest shore is bordered by bluffs that are the highest on the island.

PHYSIOGRAPHIC AND GLACIAL HISTORY

During Pliocene time, before the advance of the glaciers of the Pleistocene, Kelley's Island was a part of the mainland. The shallow depression now occupied by Lake Erie was the location of a large eastward-flowing trunk stream into which flowed tributaries from the north and south. The islands of Lake Erie, including Kelley's, were then the higher portions of the divides between the streams. The glaciers that later advanced over this section from the north and east scooped out the residual material in the stream valleys and to some extent added to the excavations that had been produced by the erosive force of the streams. The passages among the islands were finally created when Lake Erie arrived at its present level of 573 feet A. T. Because the Pliocene tributaries flowed generally northeast into the trunk stream and because the direction of dominant glaciation was from that general direction, the total effect of these two factors has been to produce the present-day, parallel, island passages that trend N. 80° E.

After the final withdrawal of the Wisconsin Ice Sheet, a lake was impounded between the glacier front to the north and the watershed on the south. As the ice-front melted to the northeast, lower outlets were uncovered causing the level of the lake to drop rapidly to the elevation of the new exits. During the successive stages of Lake Erie, known as, Lake Maumee, Lake Whittlesey, and Lake Warren, Kelley's Island remained submerged. During the Lake Lundy stage, a rectangular island of about one-third the size of the present one appeared above the surface of the cold, glacial waters. The shore of this island is evident at various places, especially prominent a short distance north of Estes School, at an elevation of 610 feet A. T. Here are abandoned, water-worn cliffs seven to eight feet high, now partially overgrown with scrub growth, but yet conspicuous and bearing adequate testimony to the fact that the Lake Lundy stage must have been of long duration to have enabled the waters to nip out these prominent cliffs in the limestone rock of the island. Near Carpenter

Point and at other locations on the island this ancient shoreline may be observed at an elevation of thirty-seven feet above the present lake level.

The next lowering of the level of Lake Erie resulted in the emergence of the western end of the lake and the confinement of the water in the eastern half of the basin. This was the final stage in the shrinkage of the post-glacial lake. Since the removel of the ice from the area of eastern Canada, the land has gradually risen and tilted the Great Lakes to the southwest. The rise of the water level in western Lake Erie has produced estuaries at the mouths of the Maumee, Portage and Sandusky Rivers, the good harbors at Toledo, Port Clinton and Sandusky. If the present rate of tilting continues, Kelley's Island will probably remain an island for perhaps the next twenty-five hundred years, after which Niagara Falls may cease to be and the Great Lakes drain into the Mississippi River by way of the Illinois River and by way of the Maumee, Wabash and Ohio Rivers.

Professor E. L. Moseley, of the Bowling Green State Normal College[1] made a thorough study of the island region and arrived at the conclusion that the rise of the water for at least the last four centuries has continued with a nearly uniform rate of about two and one-seventh feet (2.14) a century. If this rate has been uniform, according to Moseley, approximately a thousand years ago the Indians may have walked from Sandusky to Kelley's Island at any season, it being necessary to swim across only one or two streams and wade through some marsh.

Glaciation has been the dominant factor in the physiographic history of Kelley's Island and evidence of its presence is everywhere conspicuous. The islands in western Lake Erie present some of the most marked indications of glacial erosion anywhere to be found in the United States. The grooves gouged by the glaciers on the rocky shores were noticed by the first settlers of Kelley's Island (Fig. 2) and new grooves are continually being uncovered during the course of removing soil for the extension of quarrying operations.

The prominence of glacial markings is due to the fact that the soft shales to the east offered little resistance to the glacier, but the harder limestones of the Cincinnati arch were a difficult barrier to the progress of the Erie lobe. The deepest grooves

[1]Moseley, E. L. "Formation of Sandusky Bay and Cedar Point," Ohio State Academy of Science, Vol. IV, Part V.

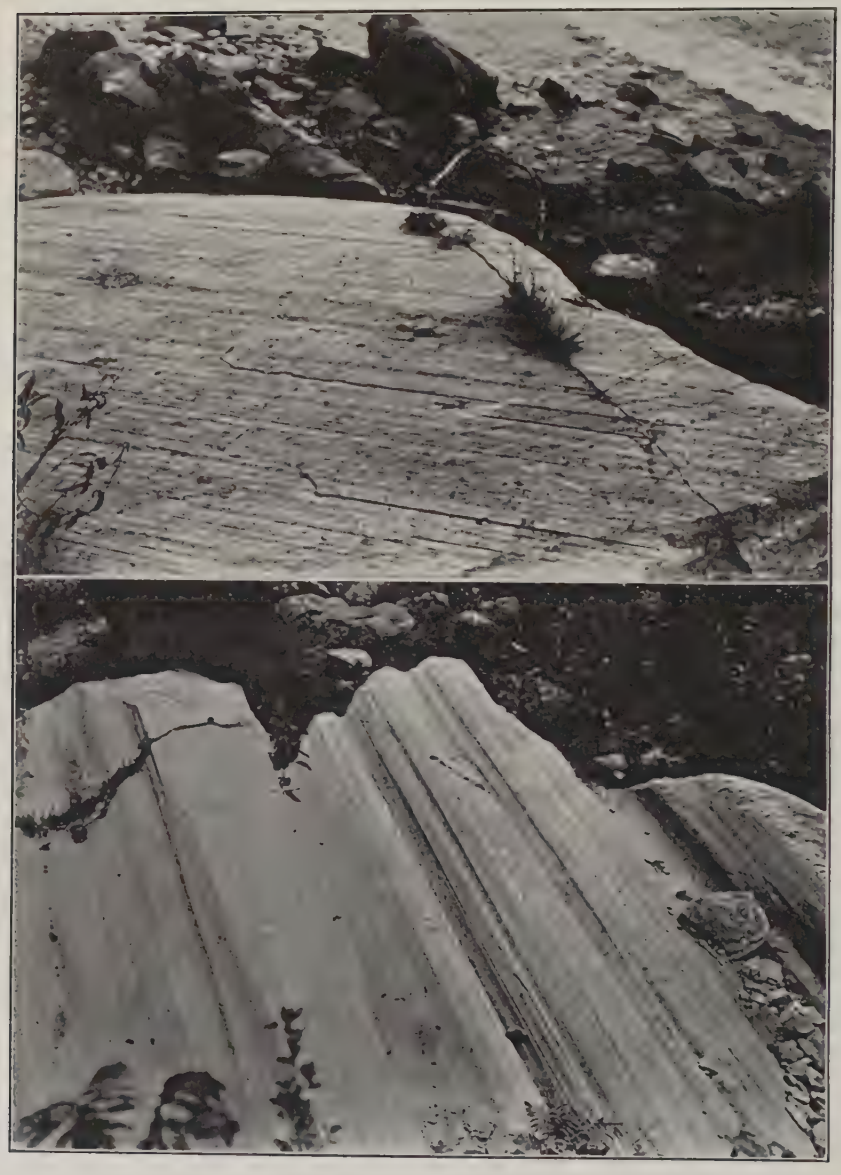

FIG. 2. (Upper.) Glaciated limestone pavement located on Long Point in the northeast portion of the island. Cross-sections of colonial corals, two to three feet in diameter, are exposed here.

FIG. 3. (Lower.) Kelley's Island glacial grooves, located at the old North Side Quarry, on the west shore of North Bay. This region is now a state park.

are found on the higher elevations of the island which were naturally more exposed to the leveling action of the ice.

Nearly all of these magnificent glacial grooves have fallen prey to the economic activity of man, and only near the northwest shore of the island may the huge gouges be seen today (Fig. 3). Here the State of Ohio has created (1931) a state park to preserve them for posterity. Unfortunately, the impress of the initial and name-chiseling vandal is too evident on the surface of these invaluable glacial carvings; since they became state property, additional names have been chiseled deeply into the grooves and further destroyed their beauty.

The Kelley's Island Glacial Grooves are located at the terminus of a line of bluffs overlooking North Bay and may easily be reached, from the steamboat dock at the foot of Division Street, by continuing northward across the island to the west shore of North Bay. The grooves are located at the edge of the old North Side quarry and were set aside by Mr. Younglove, former president of the Kelley Island Lime and Transport Company. A part of one of these grooves was acquired by the Western Reserve Historical Society of Cleveland and another portion may be seen in the National Museum at Washington, D. C. National interest in these grooves was first aroused by an excursion of the American Association for the Advancement of Science, while meeting in Cleveland, Ohio, in 1888. It is an inspiring geological phenomena—like so many Corinthian columns lying side by side. They constitute a convex surface that dips slightly (1°) S. 80° W. under four feet of overlying glacial till. Six distinct columns may be distinguished, but no two have the same size or degree of curvature. The largest is at the crest of the arched surface and is shaped somewhat like the modern steel or concrete burial vault; its crest is about five feet above the lowest groove. Chatter marks are very distinct. The columns are not all mathematically symmetrical, but in a few cases branch out or disappear. Occasionally some obstruction forced the tools of the glacier to deviate and scratch a shallow furrow at an angle to the parallel striae.

It is believed that the location of the grooves was originally the site of a small depression formed by preglacial water action, into which the ice crowded the granitic material which constituted the grooving-tool; the rasping, scratching, scraping and polishing went on concurrently and in increasing degree until

this enormous series of furrows resulted. Most of the Kelley Island grooves are straight, but some have been discovered by removal of the local till that are greatly curved and indicate the influence of preglacial or subglacial water action. There can be no doubt that there has been considerable erosion by direct action of ice, but the presence of cross-striae should warn the

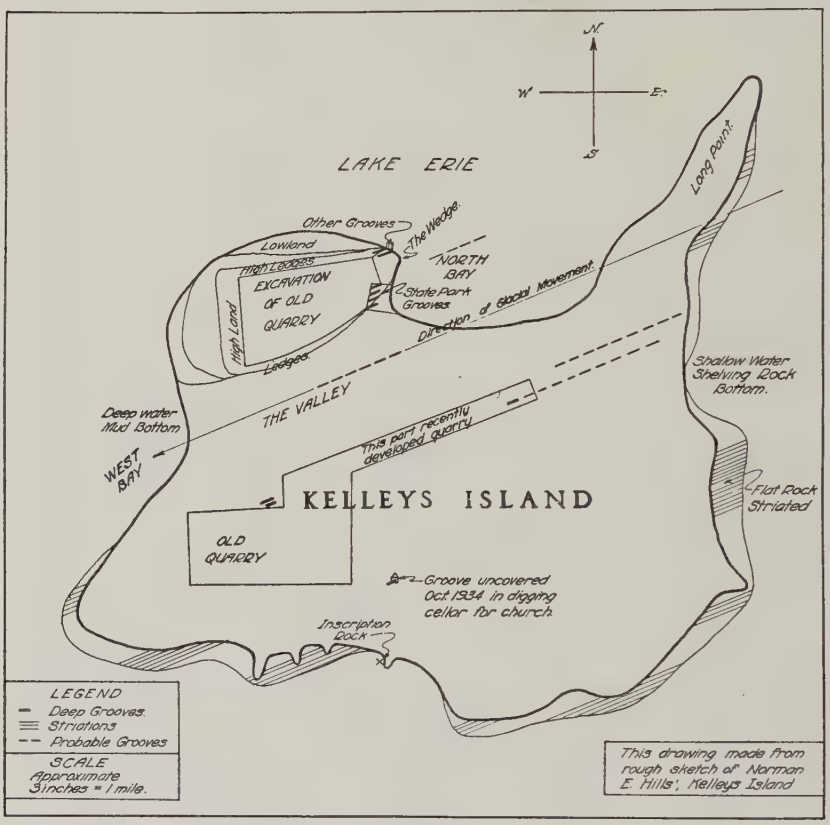

FIG. 4. Kelley's Island

geologist that the power of glacial ice to gouge out solid limestone must not be too strongly emphasized.

Four distinct, successive movements of glaciers, during the Pleistocene, are recorded by the direction of striae on the basement rock of Kelley's Island. Ice was first confined to the Lake Erie valley, but did not extend above and over the summit of the watershed to the south and consequently the lobe was

forced to move to the southwest, scooping out channels between the islands. The thickness of the ice was probably no greater than nine hundred and fifty feet. During the height of the glacial period the ice became thicker, extended over the divide of the watershed and moved from north to south, because the Illinois lobe then blocked the natural southwest outlet. The general southwest movement was resumed on the retreat of the ice front to the Lake Erie watershed and the withdrawal of the Illinois glacial lobe which blocked its path on the southwest. The markings of the previous north-south movement were obliterated on all eastward sloping rock surfaces, but on the lee side the north-south marks were protected. There was a feeble repetition of the north-south movement when the watershed no longer compelled a westerly movement. The evidence is faint, because the movement was not long continued.

On the east shore of Long Point opposite the end of the road, there is a glacial pavement of remarkable smoothness with shallow grooves plainly discernible, trending in the direction of S. 80° W. The width of this pavement varies from approximately one hundred and fifty to three hundred feet along the lake shore and is about five acres in area. The extent of the glacially-smoothed rock surface under the water of the lake is at least four times the area above water. The recency of the glacial period is strikingly shown by the sharpness of the chatter marks in the shallow grooves. This is remarkable when one considers the fierceness of the "northeasters" that beat upon this exposed shore. Nowhere on the island are there so many huge glacial erratics as lie here on the glacial pavement; many are four and five feet in diameter. Numerous and huge as are the erratics, the vast level sweep of the glacial pavement is hardly broken.

STRUCTURE AND LITHOLOGY

Kelley's Island is composed of the Columbus limestone of Middle Devonian age which is underlain by the Monroe limestone of the Upper Silurian. Since the highest elevation on the island is forty-eight feet above Lake Erie and the upper two feet of the Monroe is exposed below lake level in the quarries, all but the upper ten feet of the Columbus occurs on the island. This marks the most northerly outcrop of the formation in Ohio; here about sixty feet thick. The crest of the Cincinnati arch or geanticline is located about twenty miles

to the west and bends northeast across Lake Erie into Ontario. This is evident from the slight southeastward inclination of the Columbus strata; the dip is not noticeable in the sides of the quarries, but at the end of Long Point a local steepening is perceptible to the eye. The dip was found to be 6°, S. 40° E.

The North Side quarry is the oldest and deepest; there was an early demand for the massive grayish-brown limestone of the "bottom rock" used in breakwaters and other massive structures. An excellent view of the quarry may be obtained from the Glacial Grooves. The quarry section is readily divided into two parts, upper and lower. The upper part is a thin-bedded, fossiliferous, gray to bluish-gray limestone, about twenty feet thick which is slightly more massive toward the bottom. The lower part begins with the "bottom rock" stratum, a massive layer of brownish-gray limestone from seven to eight feet thick. The strata continues to be massive and more fossiliferous to the floor of the quarry, and is generally brown to grayish-brown with some chert layers of minor importance. The lower part of the Columbus limestone is about thirty-two feet thick which makes the total thickness of this formation in the quarry approximately fifty-two feet. One foot of the Monroe limestone has been penetrated and the important Middle Devonian-Silurian unconformity may be readily determined by the sharp faunal break, even though the Columbus and Monroe limestones are disconformable and appear to be one formation.[2]

The rapid falling off in demand for building stone and the increasing demand of crushed stone for lime, flux and road building has made it more economical to quarry only the thin-bedded upper part and some of the "bottom rock" of the Columbus. As a result almost the whole top of the island is being removed from west to east; the average depth of the vast quarry is twenty-five feet. The well-marked bedding planes and numerous joints make the upper part of the Columbus limestone easy to quarry. The abundance of cracks and joints may have been in part the result of subsequent uplifts of the Cincinnati arch; the majority of the vertical planes trend parallel to the axis of the arch which in this part of Ohio is in a direction of N. 30° E. The upper part of the Columbus is a very pure limestone and therefore valuable for

[2]C. R. Stauffer. "The Middle Devonian of Ohio," Geological Survey of Ohio, Fourth Series, Bulletin 10, p. 137.

use as lime and flux. Analyses disclose increasing proportions of magnesium carbonate and decreasing proportions of calcium carbonate from the top to the bottom. In the upper beds the amount of $CaCO_3$ is as high as 97% and the amount of $MgCO_3$ is as low as 2%, whereas the lower massive beds run as low as 78% $CaCO_3$ and as high as 20% $MgCO_3$. Alumina, iron oxide and silica make up the remaining 2%.

The Columbus limestone of Kelley's Island is very fossiliferous; corals are especially numerous. The most conspicuous are the huge colonial corals which occur in colonies from three to six feet in diameter. Excellent transverse sections of the corallites are exposed on the glaciated surfaces of the island. Individual horn corals may be easily found, of these are: *Cystiphylum Ohioense*, *Zaphrentis Wortheni* and *Zaphrentis Edwardsi*.[3] The Middle Devonian is noted for the huge fishes that swam in its seas and their fossilized remains are frequently found; the most important that have been recovered are the jaws of the *Onychodus*, which are a foot long and studded with sharp pointed teeth.

ECONOMIC

The Labradorian Glacier scraped all the residual soil from the rocky surface of Kelley's Island and deposited a shallow cover of glacial till that was thinned further by the waves of the shrinking Lake Erie. Over much of the area, grass barely clings to an inch or two of soil; nowhere is the island surface more than two and a half feet above solid rock. Such a thin covering of earth is difficult to cultivate and is more suitable for the growing of vineyards and fruit trees, especially so, since the soil is well charged with lime derived from the disintegration of the underlying rock. The success of grape culture also has been dependent on the equable lake climate that is notably free from late spring and early autumn frosts.

The cedar forests that originally covered the entire island were among the first sources of revenue for the early dwellers. So abundant was this beautiful wood that it supplied building material and fuel. The "Walk-in-the-Water," the first steamer to ply the waters of Lake Erie (1818), was supplied with fuel by the red cedar of Kelley's Island; this ship was wrecked in 1820 in a storm. The red cedar forests rapidly disappeared

[3]Geological Survey of Ohio, Second Series, Vol. II.

before the woodman's ax and today only a few trees are found scattered on the bluffs. The primeval forest was composed also of white oak on the high land, maples, hickory and hackberry on the lower and more level surface, and sycamore on the low marshy ground near the shore of North Bay. Only six acres were cleared in 1833.

Vines of the wild grape were abundant and large. The first cultivated variety was set out in 1842 from cuttings brought from Rockport, New York, but it was not until 1854 that there was a large increase in acreage. Some Germans who had come from the wine districts of the old world found employment on the island and realized its favorable climatic and soil conditions. The price of land then rose rapidly from fifty dollars to as high as one hundred and twenty-five dollars per acre. Grape rot did not appear until 1862 and for eighteen years no frosts harmed the grape crop. The wine industry increased until after the World War when the storage capacity of the Kelley's Island wine cellars was more than half a million gallons.

The residents derive considerable income from the summer tourists who are attracted by the fishing and quiet of the island. Commercial fishing is an important economic activity during the Spring and Fall. Fish abound on the nearby shoals and are caught in such quantities that the island region ranks high in the fresh water fish industry of the United States. The fish are brought to the island docks from where they are collected and transported to the large wholesale houses in Sandusky for shipment mainly to Chicago and New York markets.

Quarrying is the leading industry of Kelley's Island. Limestone was first quarried in 1833 on the north side and the first shipment was made from a pier on North Bay in the following year. Quarrying is easy and economical, because the loose, thin layer of soil may be rapidly removed from above the limestone. Quarries were later developed on the south and west sides, but today the north and south loading-docks are abandoned and all stone is dumped into freighters and barges from a modern elevated pier on the west shore. Much stone, well adapted for building purposes, was formerly sold, but this use has largely been abandoned and now all the limestone is crushed and sent to Cleveland, Buffalo and Gary for flux or to Duluth to be burned into lime. The Kelley Island Lime and Transport Company formerly burned lime on the island

and at Sandusky, until it was found to be more economical to burn the stone near the markets or the source of fuel supply. At one time sixteen lime kilns operated near the North Bay docks at a capacity of sixteen hundred barrels of lime per day. Cooperage shops were maintained at the time. The population of Kelley's Island during this period of great activity was more than a thousand, but has since decreased to six hundred and thirty-eight, according to the 1930 census. The new modern use for crushed stone in the manufacture of cement, tile and building blocks and the repeal of prohibition are new factors that will tend to aid the economic situation of Kelley's Island.

Antillean-Caribbean Geology

The first volume of Charles Schuchert's Historical Geology of North America concerns the stratigraphy and historical geology of the "Antillean-Caribbean Region, or the Lands Bordering the Gulf of Mexico and the Caribbean Sea." In this compendium the summary comes first. Here Schuchert considers the greater geologic features, diastrophism, and paleogeography. In section II are considered the ancient Caribbean Mediterranean, the Antillean Sea and the young Gulf of Mexico. Section III takes up the biogeography and presents the biogeographic evidence bearing on the problem. These three sections take up 113 pages. Section IV takes up in detail the lands. Here we find the geologic history of Mexico, Gulf Coastal Plain, Nuclear Central America, the Antilles, the young Isthmian link connecting Central and South America, Northern South America, and the Oceanic Islands. This is the major portion of the book covering some 654 pages.

It is impossible to do justice to this volume in the space available. Schuchert rejects the Wegenerian theory of continental drift and states that the "continuous linking of fold mountains does not exist in nature and the theory must be abandoned." He also does not believe in a land bridge, as do most zoogeographers, from Yucatan to Cuba and Hispaniola. He considers that the present Greater Antilles are fragments of a greater Central America. There was no land bridge between North and South America in the Permian (plants), Triassic (reptiles), or Jurassic (dinosaurs), but a land connection first appeared in late Cretaceous to early Eocene times. During late Eocene to middle Miocene it was broken by flooding as it was in early Pliocene. From middle Pliocene to the present it has not been broken. In pre-late Eocene times Central America continued eastward forming a long Antillean peninsula reaching to the Virgin Islands and The Banks. The paleogeography is illustrated by a series of 16 maps showing the changes from Middle Pennsylvanian to upper Pliocene-Pleistocene. There are geological maps for most of the areas discussed. Needless to say, these are small scale and show the distribution only of the larger divisions of the rocks. They are for the most part taken from available sources, some unfortunately being fairly old, as no newer ones are available. There is a good bibliography at the end of each section which gives the important papers on the various regions. An extremely complete index winds up the volume.

Although the reviewer does not entirely agree with Dr. Schuchert in his interpretation of some of the evidence, he can heartily recommend this book. It brings together the geology of the region around the Gulf of Mexico and the Caribbean Sea, making it available in one volume. This is very convenient for graduate students and those who handle advanced courses in geology. We wish the book success.—WILLARD BERRY.

Historical Geology of the Antillean-Caribbean Region, by Charles Schuchert. xxvi+811 pp. New York, John Wiley and Sons, Inc., 1935.

THE ALIMENTARY CANAL OF THE ORIENTAL FRUIT MOTH LARVA

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The oriental fruit moth, *Grapholitha molesta* Busck, was first found in Ohio in 1925 but spread rapidly throughout the State and has now become the major peach pest. Although the literature dealing with this insect has become voluminous, so far as the writer is aware, practically nothing has been published on the internal morphology of the insect. It seemed desirable, therefore, that such a study be undertaken.

The writer has been engaged in a study of the biology and control of the oriental fruit moth at the Ohio Agricultural Experiment Station for a number of years and, consequently, had an abundance of live material available. Fresh material, consisting of full-grown hibernating larvae, was used in all dissections. The larvae were killed in hot water and dissected either in saline solution or in tap water. The stains used in the preparation of slides were limited chiefly to Haemalum and Fast Green FCF—Haemalum for nuclei and Fast Green for cytoplasm and cell walls.

The larva of the fruit moth, as well as the other stages of the insect, has been described by Garman (1), Peterson and Haeussler (4), and Stear (5); consequently, no further description will be included here.

The position of the different parts of the digestive tract in relation to the body segments varies with the degree of extension of the body. The description given here is that of the digestive tract of a larva in which the body segments are partly extended.

Gross Anatomy of the Digestive Tract

The alimentary canal of the oriental fruit moth is a straight tube extending from the mouth to the anus (Fig. 1). The fat-body forms a sheath almost completely surrounding the tract and apparently supports

Note: This study was begun at Ohio State University in a course on "The Morphology and Development of Insects," given by Dr. C. H. Kennedy. The writer desires to express his appreciation to Dr. Kennedy for his suggestions and criticisms.

it to some extent. The canal is constricted locally, and the three main divisions—the fore-intestine, mid-intestine, and hind-intestine—are rather easily distinguished. The various parts of these divisions are not very evident from a superficial examination.

FORE-INTESTINE, SALIVARY GLANDS, AND SILK GLANDS

The pharynx, which is very small, is located within the head. Arising from the pharynx are bundles of muscles attached to the head capsule.

Two salivary glands open separately into the mouth beside the pharynx. These glands consist of two long, coiled tubes, one on each side of the alimentary canal, which lie in folds chiefly in the region of the thorax. The anterior end, which lies very close to the pharynx, becomes exceedingly small and is closely enclosed in muscles.

The silk glands also consist of two tubes, one lying on each side of the digestive tract. The two tubes are similar and extend, with many convolutions, in a caudal direction as far as the fourth abdominal segment. They lie in folds in the adipose tissue and, when fully extended, are approximately as long as the body of the larva. The two tubes become smaller anteriorly and join together in the head on the ventral side of the pharynx. They become very small at this point and were not traced further.

A slight constriction in the alimentary canal back of the head indicates the beginning of the oesophagus. There is no apparent distinction between the oesophagus and crop. At approximately the middle of the metathorax a distinct, abrupt enlargement indicates the beginning of the mid-intestine.

MID-INTESTINE

The mid-intestine, which constitutes more than half of the entire length of the alimentary canal, continues without much change except a slight decrease in diameter from the metathorax to the sixth abdominal segment. A distinct enlargement in this segment indicates the pyloric valve and the beginning of the hind-intestine.

HIND-INTESTINE

The attachment of the malpighian tubes just posterior to the pyloric valve also marks the beginning of the small intestine. These tubes arise in two small pouches or bladders (Figs. 1 and 7), one on each side of the anterior end of the ileum. These pouches apparently are structures about which little is known. Similar pouches have been figured, however, by Peterson (3) for the tomato worm, *Protoparce sexta* Johan. One tube arises from each pouch and extends anteriorly a short distance to approximately the anterior end of the sixth abdominal segment, where each tube divides. The four tubes then continue in a cephalic direction along the walls of the mid-intestine to the anterior portion of the fourth abdominal segment. At this point one tube on each side divides again, forming six tubes. These turn abruptly and, with many convolutions, follow caudad along the walls of the alimentary canal to the rectum. All of the six tubes enter the walls of the rectum.

The ileum is a narrow, straight tube extending to the posterior portion of the eighth abdominal segment. A slight stricture followed by a bulb-like enlargement indicates the colon, which is short. The rectum appears as a distinct enlargement just posterior to the colon.

Histology of the Alimentary Canal

FORE-INTESTINE

A histological examination of the fore-intestine revealed no unusual structures. The chitinous inner lining, or intima, is prominent and in the proventriculus, chitinous teeth are very evident (Fig. 3). Cell walls in the epithelium were not distinct in the slides prepared, but nuclei were prominent. Longitudinal muscles appear in isolated strands inside a continuous layer of circular muscles. The circular muscles are large, as shown in Figures 2 and 3.

The oesophageal valve is well developed and marks the division between the fore- and mid-intestine.

MID-INTESTINE

In the mid-intestine the cells of the digestive epithelium apparently vary in size and shape, depending upon their physiological condition at the time the insect was killed. In most of the specimens studied the cells were long and narrow as shown in Figure 4, and the inner edge indicated holocrine secretion. In a few specimens the cells were short and gave little evidence of a broken or striated border. The nuclei are prominent and usually lie near the base of each cell. The muscles are much smaller than in the fore-intestine, and the longitudinal muscles lie in strands outside the continuous layer of circular muscles. The longitudinal muscle strands are much more numerous than in the fore-intestine and occur at regular intervals around the stomach.

HIND-INTESTINE

The hind-intestine, as mentioned previously, is marked anteriorly by the pyloric valve and the attachment of the malpighian tubes. The pyloric valve (Fig. 6) consists of long, fan-shaped epithelial cells.

The cells of the malpighian tubes are large and spongy, with the inner border distinctly striated (Fig. 11). An enlarged section of one of the pouches in which the tubes arise is shown in Figure 7. The walls contain a distinct muscular layer and the epithelium of the ileum apparently extends into the pouch.

The ileum in cross section appears similar to the oesophagus. The circular muscles are large and the inner lining is prominent.

The colon, as shown in Figure 8, is apparently a bulb-like enlargement of the hind-intestine and is marked by large circular muscles.

A cross section of the rectum (Figs. 9 and 10) shows a continuous row of malpighian tubes inside the walls. The tubes lie between the epithelial tissue and a double, thin membrane which has been described by Ishimori (2). However, Ishimori described two rows of malpighian vessels inside the walls of the rectum in Lepidopterous larvae, but the writer has been able to distinguish but one in the fruit moth.

The chitinous inner lining of the rectum is prominent, and the longitudinal muscles appear in large isolated strands outside of the layer of continuous circular muscles.

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EXPLANATION OF PLATES

Plate I

Fig. 1. Diagrammatic dorsal view. Salivary gland and malpighian tube pulled out of position to show approximate length.
Fig. 2. Cross-section through the oesophagus.
Fig. 3. Cross-section through the lower end of the oesophagus or proventriculus showing the chitinous teeth.
Fig. 4. Cross-section through the mid-gut.

Plate II

Fig. 5. Cross-section through the ileum, or small intestine.
Fig. 6. Longitudinal section through the pyloric valve showing a pouch from which the malpighian tubes arise.
Fig. 7. An enlarged longitudinal section through a pouch or bladder.
Fig. 8. Longitudinal section through the colon and rectum.
Fig. 9. Cross-section through the rectum.
Fig. 10. An enlarged portion of a cross-section through the rectum, showing the row of malpighian tubes.
Fig. 11. Cross-section through a malpighian tube.

SYMBOLS USED IN PLATES

BL.....Bladder of malpighian tube.
C. M....Circular muscle.
COL.....Colon.
C. TIS...Connective tissue.
EPI.....Epithelium.
H. I.....Hind-intestine.
IL.....Ileum.
INT.....Intima, or inner chitinous lining.
L. M....Longitudinal muscle.
M. I.....Mid-intestine.
M. T....Malpighian tube.
OES.....Oesophagus.
PH.....Pharynx.
P. V.....Pyloric valve.
REC. ..Rectum.
S. B.....Striated border.

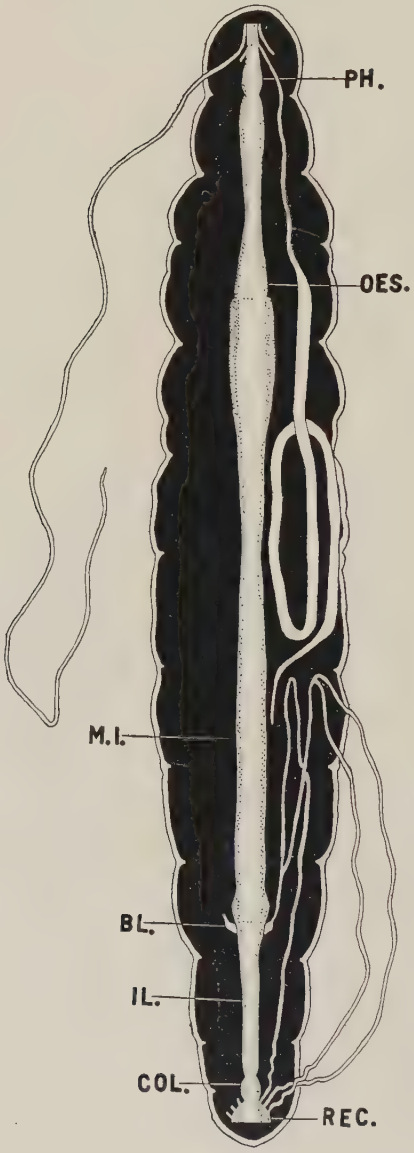

FIG. 1

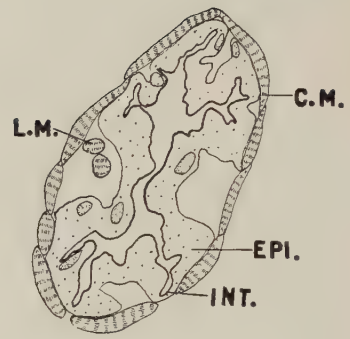

FIG. 2

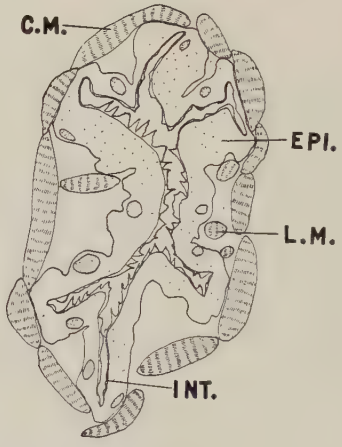

FIG. 3

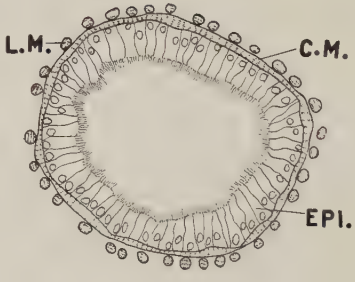

FIG. 4

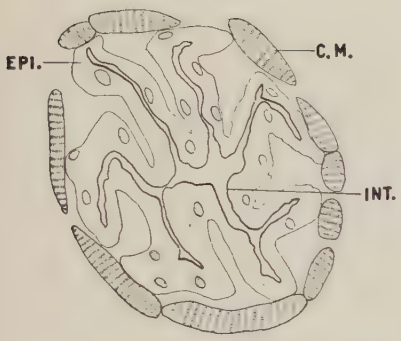

FIG. 5

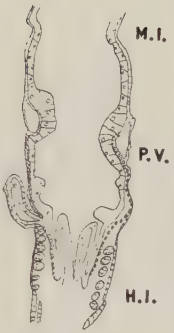

FIG. 6

FIG. 7

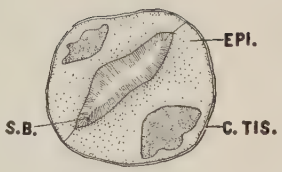

FIG. 11

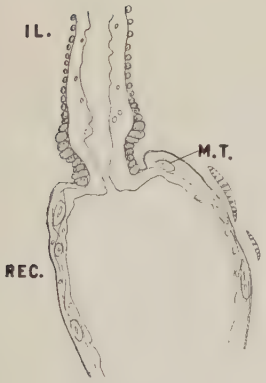

FIG. 8

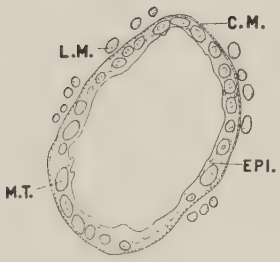

FIG. 9

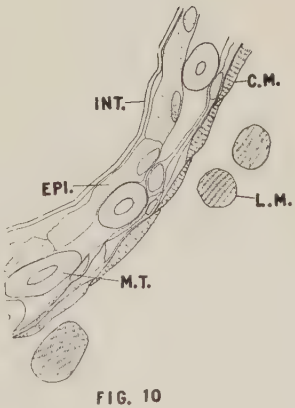

FIG. 10

THE EXTERNAL MORPHOLOGY OF HYDROUS TRIANGULARIS (HYDROPHILIDAE: COLEOPTERA)

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INTRODUCTION

The water-scavenger beetles live upon decomposing vegetable matter. They are found in the shallow water of quiet lakes and ponds, among the plants growing on the bottom. This study was made principally at the Franz Theodore Stone Laboratory of Ohio State University at Gibraltar Island, Put-in-Bay, Ohio. The greater part of the work was done with preserved material. One specimen was taken in a quiet pool on the shore of North Bass Island.

Hydrous triangularis is one of the larger species, having a length of 35 to 39 mm. and a maximum width of 14 to 17 mm. This genus is found in all parts of the United States and contains some of the largest and smallest members of the family.

The nomenclature used by the writer is adapted from the literature of such entomologists as Snodgrass, Korschelt, Imms and others.

This study was suggested by and made under the direction of Dr. C. H. Kennedy, of the Ohio State University, to whom the writer wishes to express sincere thanks for his many helpful criticisms and suggestions.

THE HEAD

(Pl. I, Figs. 1 to 11)

The head capsule is rounded and about as long from the occipital foramen to the anterior margin of the labrum as it is wide between the eyes. The frontal sutures extend diagonally from the anterior margin of the eyes to the coronal suture which divides the vertex longitudinally. The head is normally partly withdrawn into the prothorax. The dorsal part of the vertex and clypeus are coarsely punctate. (Pl. I, Fig. 1).

The mouth-parts are in front of the head and the head is dorsoventrally flattened. The ventral wall of the hind part of the head is formed by the gula, which extends from the occipital region to the submentum. The gula is elongate and is bounded laterally by the

gular sutures. The surface of the gula is separated from that of the submentum by a dividing suture. (Pl. I, Fig. 10.) A definite mentum is present. (Pl. I, Fig. 3.) In the grasshopper and other more primitive insects, the head is antero-posteriorly compressed and the mouth-parts are beneath the head. In the grasshopper a sclerite corresponding to the gula is not present, because of the short distance between the base of the submentum and the cervix.

The mandibles have five teeth and a retinaculum is prominent as a soft semicircular shelf between the premolar and molar regions. (Pl. I, Fig. 7.) The galea, digitus and lacinia of the maxillae are profusely marginate with long hairs. A prominent palpifer and subgalea are present and from the former arises the six-jointed palpus. A basal piece or cardo is present. (Pl. I, Fig. 4.) The labium bears two four-jointed palps, between which are the paraglossae. (Pl. I, Fig. 10).

The lamellate antennae are nine-jointed and are attached to the ventral side of the head between the eyes and the bases of the mandibles. (Pl. I, Fig. 11.) Attached to each lateral margin of the head is a large compound eye. These constitute a large part of the surface of the head.

The tentorium (Pl. I, Fig. 3) is braced in the occipital region by two posterior tentorial arms. Each dorsal arm of the tentorium arises from the sides of the body of the tentorium, between the anterior and posterior arms. These support the dorsal part of the head in the region of the antennal sclerite. Each anterior tentorial arm opens on the head posterior to the mandible.

THE PROTHORAX

(Pl. I, Fig. 9)

The anterior margin of the prothorax as seen from below is concave and the posterior and lateral margins convex. It is about half as wide along the anterior margin as it is along the posterior margin. The dorsal side is entirely covered by a plate-like pronotum. (Pl. I, Fig. 9.)

On the ventral side are two large propleural plates. (Pl. I, Fig. 9.) Anteriorly these extend from the pronotum to the lateral margin of the precoxal-bridge, (Pl. I, Fig. 9), and posteriorly as a narrow point projecting mediad back of the coxal cavity. The coxal cavities are between the median projections of the propleural plates and the lateral arms of the precoxal-bridge.

The legs of the water-scavenger beetle readily distinguish it from the predacious diving-beetles. Those of the former are equidistant whereas the middle and hind pair of legs are widely separated in the latter. In the male of *Hydrous triangularis*, the fifth joint of the tarsus has a cushion-like enlargement on the inner side called the empodium. The female tarsus consists merely of five normal joints.

THE MESOTHORAX

(Pl. II, Figs. 12, 13, 15, 16)

The meso- and metathorax are very closely connected and give the appearance of a single unit. The mesothorax is the shortest of the three thoracic segments. The largest area of the mesonotum is occupied by a smooth triangular plate, the prescutum. (Pl. II, Fig. 12). The

extreme anterior corners of the prescutum are produced into two hooks or clavicola. From the antero-lateral margins of the prescutum arise the articulations of the elytra. The articular sclerites of the elytra are not shown. The metepisternum and mesopleurum are united dorso-anteriorly by the mesopleural suture. (Pl. II, Fig. 13.)

On the ventral side the largest area of each mesopleurum is occupied by the episternum. This is an elongate sclerite that lies antero-lateral to the basisternum. The episternum and epimerum are divided obliquely by the pleural suture, the lower end of which articulates with the coxa. Meeting the upper end of the pleural suture at right angles is another suture that divides the episternum into supra- and infra-episterna. (Pl. II, Fig. 15.) Extending the length of and beyond the meso- and metathorax is a median spine-like structure, the sternum. This is crossed at the base of the mesothorax by a fine suture. Internally the furca (Pl. II, Fig. 16) arises as two median apodemes. These are connected immediately anterior to the coxae by a furcal ridge. Each branch of the furca is continued at its apical (anterior) end in two free distal arms. One arm extends antero-laterally beneath the episternum, the other as a lateral extension beneath the epimeron.

THE METATHORAX

(Pls. II and III, Figs. 12 to 17)

Posterior to and below the prescutum of the mesothorax is a median groove which lies between the scuto-scutellar sutures. (Pl. II, Fig. 14.) These extend the entire length of the scutum. The scutum is bounded anteriorly by two antero-lateral projections of the scuto-scutellar suture and laterally by the articular processes of the wings. These projections of the scuto-scutellar suture and the articular processes of the wings mark the anterior limit of the metathorax. The articular sclerites of the wings are not shown. Anterior to the metathoracic coxa and on the dorsal surface under the outer edge of the folded wing is a narrow triangular sclerite, the metapleurum. (Pl. II, Fig. 13.) This narrows anteriorly and is connected with the metepisternum by the metapleural suture (Pl. II, Fig. 13), which lies parallel to and just dorsal of the lateral edge of the metathorax. A continuous and definite suture between meso- and metathorax is not present. The prescutum is only loosely connected with the scutum. Medially the connection consists of a transparent membrane, laterally the pleural hooks (Pl. II, Fig. 12) are fused with the lateral margin of the scutum by a membranous structure.

Internally a Y-shaped apodeme, the metathoracic furca (Pl. II, Fig. 16), supports the metathorax. The base of this process arises between the metathoracic coxae. This median apodeme extends dorso-anteriorly toward the metanotum. A short distance below the metatergum arise the two arms.

On the ventral side, the metasternum and episternum are divided by a heavy suture. The episternum is similar to that of the mesothorax except there is no suture dividing it into supra and infra-episterna. The epimeron is not seen from below but is a narrow oblong structure attached to the lateral margin of the episternum and lies

on the dorsal edge of the metathorax. The metathoracic coxa (Pl. II, Fig. 15) has the appearance of another thoracic sclerite. Its ventral surface appears in the form of a flattened elongate plate which extends diagonally from the posterior end of the metapleural suture mediad and caudad to the sternal spine. The coxa is attached along the posterior margin of the metathorax. The attachment is such as to give it a restricted hinge-like movement. Inserted between the posterior edge of the wing of the metasternum and the anterior edge of the coxa is a narrow plate which is probably a much elongate trochantin (Pl. II, Fig. 14) which articulates with the coxa at its inner end. The peculiar structure of the coxa is a distinguishing characteristic of the family.

The wings are membranous and are normally folded beneath the elytra. The venation (Pl. III, Fig. 17) is much reduced. As in the Cantharid (Imms' Ed. 3, Fig. 469, p. 484, 1934) type M_1 and M_2 coalesce distally forming a very definite loop. From the point of junction M_2 is continued to the wing margin. The four anal veins and the first cubitus are distinct. Cubitus two is present but much reduced. The costal and radial veins are clearly seen near the costal margin.

THE ABDOMEN

(Pl. III, Figs. 18 and 19)

There are nine more or less cylindrical segments in the abdomen. The dorso pleural line (Pl. III, Fig. 19) divides the heavily chitinized hypopleurites from the membranous epipleurites. The pleuro ventral line is seemingly an evaginated rounded suture separating the hypopleurites from the sternal plates. Implanted in the membranous epipleurites are eight spiracles (Pl. III, Fig. 18). This number corresponds to the number of epipleurites.

Tergites 1, 2, 3, 4, 5, and 6 are normally covered by the elytra, and appear as tough membranous structures due to a reduction of the chitinization. The seventh and eighth tergites are normally exposed beyond the end of the elytra and are heavily chitinized. The ninth is usually withdrawn under the eighth tergite. The intersegmental membrane of tergites one and two has been obliterated by a definite fusion of these segments. Tergite ten, if present, cannot be differentiated from the ninth.

It is very likely that the first visible sternite contains elements of more than one abdominal segment but they are not indicated by sutures or lines. Five ventral plates or sternites are visible on the abdomen. The first three anterior plates are apparently fused and sternites eight in the female and sternites eight and nine in the male are normally withdrawn within the seventh. The first sternite is produced medially into a short process called the intercoxal process. This extends anteriorly between the metacoxae.

THE MALE GENITAL ORGANS

(Pls. III and IV, Figs. 20, 22, 23, 24)

The ninth sternum is present in the male. A membranous genital chamber arises within the ninth segment. The anus opens beneath the posterior end of the ninth tergite. (Pl. IV, Fig. 23.) The ninth

sternum (Pl. IV, Fig. 23) is extended posteriorly forming a single supporting structure for the genital chamber. Snodgrass (Smith. Misc. Coll., Vol. 85, p. 91, 1931) believes that the movable claspers or parameres (Pl. IV, Fig. 22) are homologous with the styli of the female. Between the two heavily chitinized parameres is a median intromittent organ, or penis. (Pl. IV, Fig. 22.) The penis is a membranous tubular structure bearing the opening of the ejaculatory duct or gonopore at its extremity. The gonopore opens ventrally. A chitinous median plate called the dorsal median strut extends along its dorsal surface. A similar but smaller ventral median strut extends along the ventral surface of the penis. A pair of basal plates underlap the anterior ends of the parameres. The basal plates arise behind the ninth sternite. They are united by the pons basalis into a single V-shaped structure. (Pl. IV, Fig. 24.)

Immediately anterior to the proximal end of the penis is the seminal vesicle. (Pl. III, Fig. 20.) This appears as a ball-like widening of the ejaculatory duct. Anteriorly the seminal vesicle is continued as a narrow tube to which the accessory glands are joined ventrally. In the region of these glands arise the vasa deferentia. Each vas deferens forms the outlet for a testicular tube.

THE FEMALE GENITAL ORGANS
(Pls. III and IV, Figs. 21, 25, 26, 27)

In the female the sternum of the ninth segment appears to be absent. The ninth tergite consists laterally of two narrow lateral projections and medially of a triangular sclerite. (Pl. IV, Fig. 25.) The appendages of the eighth and ninth segments are remotely similar to those of the orthopteran insects. This generalized structure of the genitalia suggests a primitive structure. These genital appendages are absent or rudimentary in many groups of insects, but their wide distribution throughout the orders leaves little doubt of their being primitive structures. The first valvulae are short pointed projections that are supported by two basal plates or valvifers. (Pl. IV, Fig. 27.) Anterodorsal to the first valvifers are two lobe-like structures, the second valvifers. The second valvulae are absent. The second valvifers are the basal plates of the third pair of valvulae. The third valvulae consist of a long pair of blades each of which is provided with a distal stylus. These appendages of the eighth and ninth segments of the abdomen are potentially gonopods because of the association of the genital openings with these segments. The gonopore opens in the region between the second valvifers. (Pl. IV, Fig. 27.) The anal opening is immediately beneath the ninth tergite. (Pl. IV, Fig. 27.)

Internally a large sac-like structure extends into the eighth segment. (Pl. III, Fig. 21.) This is continued anteriorly as the seminal receptacle, and posteriorly as the bursa copulatrix. Opening into the bursa copulatrix is the vagina which connects with the paired oviducts. Each ovary is composed of three separate egg-tubes or ovarioles.

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EXPLANATION OF PLATES

External anatomy of *Hydrous triangularis* Say

Plate I

Fig. 1. Head, dorsal view. Fig. 2. Head, ventral view. Fig. 3. Inside view of head showing tentorium from dorsal side. Fig. 4. Dorsal view of left maxilla. Fig. 5. Ventral view of left maxilla. Fig. 6. Ventral view of right mandible. Fig. 7. Lateral view of right mandible. Fig. 8. Dorsal view of right mandible. Fig. 9. Ventral view of prothorax. Fig. 10. Labium, ventral view. Fig. 11. Dorsal view of left antenna.

Plate II

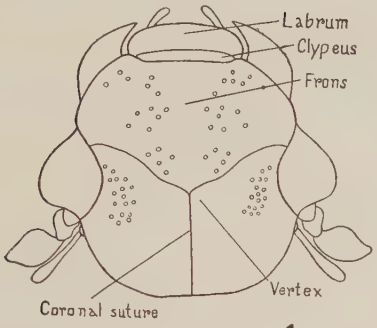
Fig. 12. Mesothorax, dorsal view. Fig. 13. Meso- and metathorax, dorsal view. Fig. 14. Metathorax, dorsal view. Fig. 15. Ventral view of meso- and metathorax. Fig. 16. Internal view of meso- and metathorax, showing furcae, dorsal side removed.

Plate III

Fig. 17. Left wing, ventral view. Fig. 18. Dorsal view of abdomen. Fig. 19. Lateral view of abdomen. Fig. 20. Male reproductive system. Fig. 21. End segments of abdomen showing female reproductive system.

Plate IV

Fig. 22. Dorsal view of postabdomen of male, abdominal segments 8 and 9. Fig. 23. Lateral view of postabdomen of male, abdominal segments 8 and 9. Fig. 24. Ventral view of postabdomen of male, abdominal segments 8 and 9. Fig. 25. Dorsal view of postabdomen of female, abdominal segments 8 and 9. Fig. 26. Ventral view of postabdomen of female, abdominal segments 8 and 9. Fig. 27. Lateral view of postabdomen of female, abdominal segments 8 and 9.



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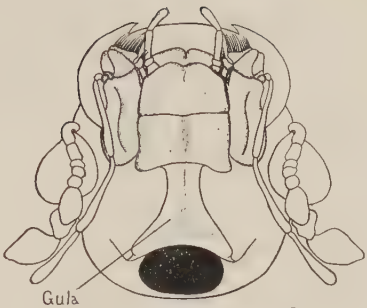

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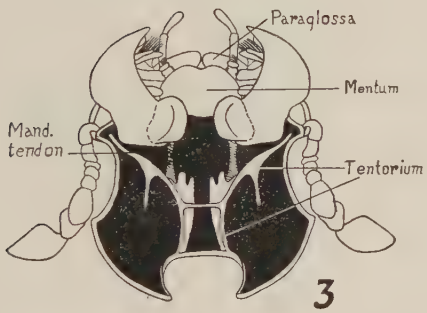

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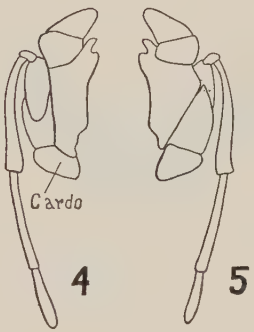

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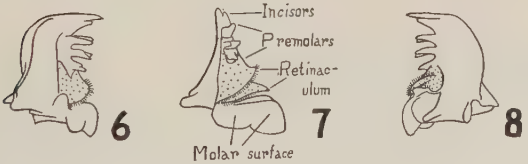

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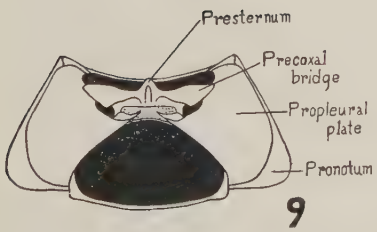

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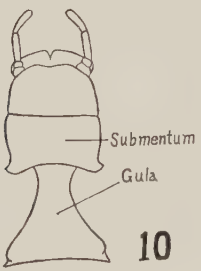

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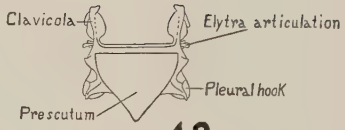
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Pleural hook
Prescutum

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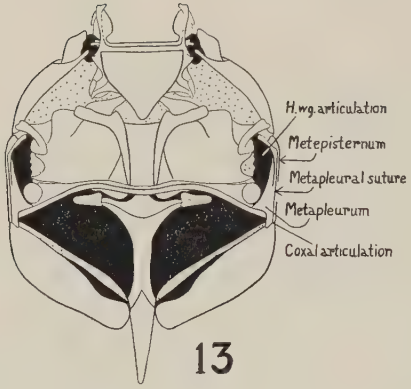
H.wg.articulation
Metepisternum
Metapleural suture
Metapleurum
Coxal articulation

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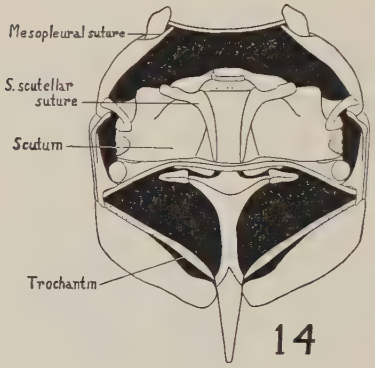
Mesopleural suture
S. scutellar suture
Scutum
Trochantin

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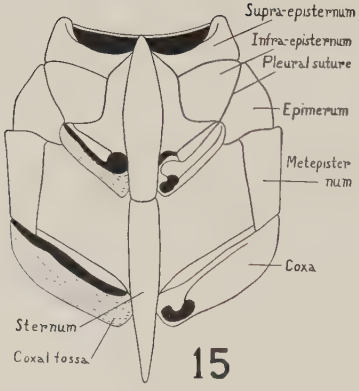
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Infra-episternum
Pleural suture
Epimerum
Metepister num
Coxa
Sternum
Coxal fossa

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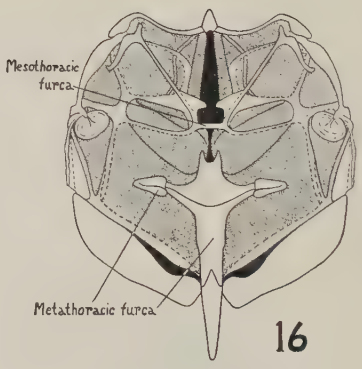
Mesothoracic furca
Metathoracic furca

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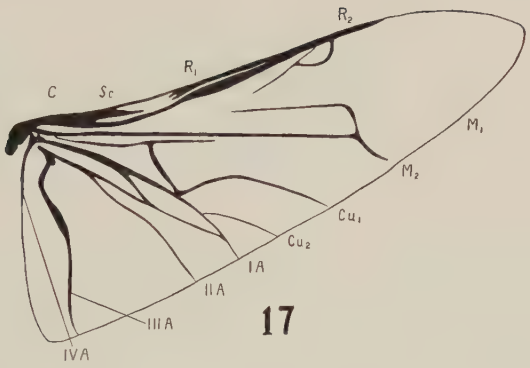
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IIA
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IVA

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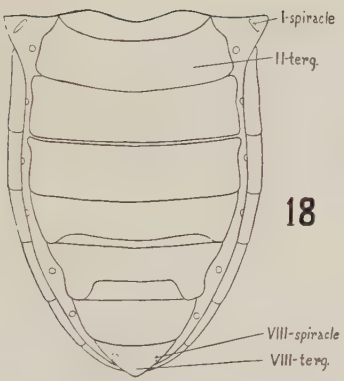
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II-terg.
VIII-spiracle
VIII-terg.

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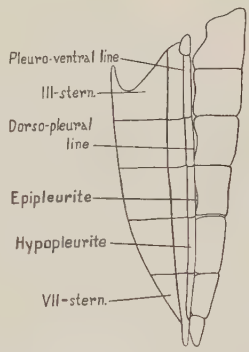
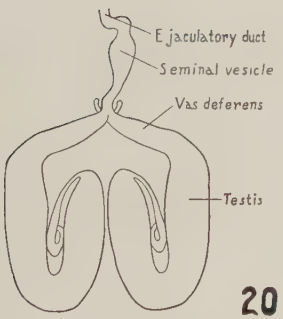

Pleuro-ventral line
III-stern.
Dorso-pleural line
Epipleurite
Hypopleurite
VII-stern.

19


Ejaculatory duct
Seminal vesicle
Vas deferens
Testis

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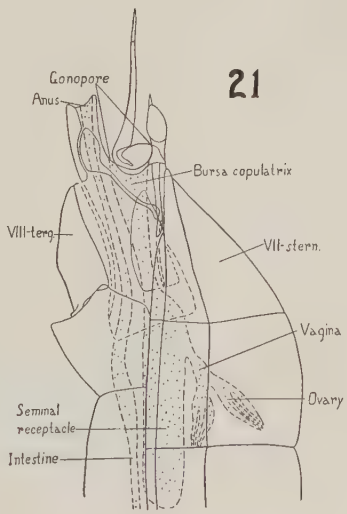
Gonopore
Anus
Bursa copulatrix
VIII-terg.
VII-stern.
Vagina
Ovary
Seminal receptacle
Intestine

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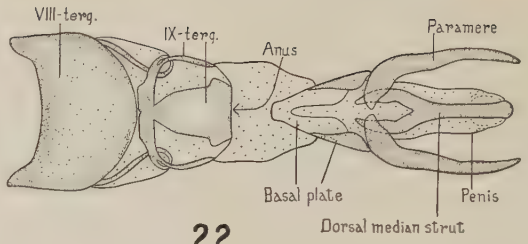

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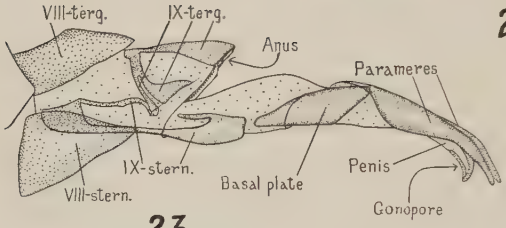

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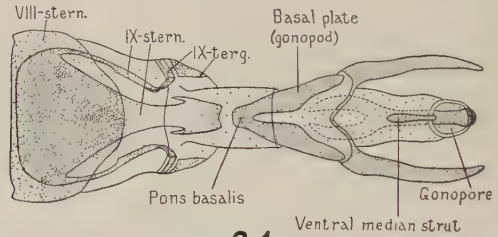

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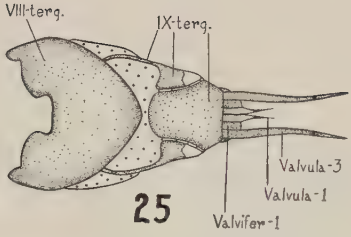

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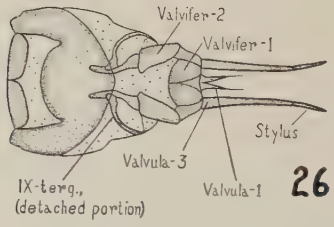

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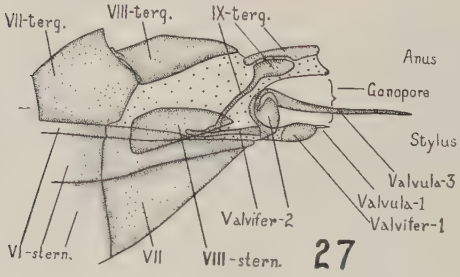

27

NEW RECORDS OF OHIO DRAGONFLIES (ODONATA)

DONALD J. BORROR
Department of Zoology and Entomology
Ohio State University, Columbus, Ohio

The latest complete list of Ohio dragonflies (Kellicott, 1899) lists 99 species. Since that time new records have been added by various workers, the last published records (Borror, 1930) bringing the list up to 116. During the last few years eleven new records for the state have been obtained, some of which are of unusual interest.

The new records for the state are as follows:[1]

117. *Lanthus albistylus* Hagen. Loudonville: 1♂, 3♀, and 6 exuviae June 6, 1915, J. S. Hine (DZE). Although these specimens were taken a number of years ago, the records were never published. This is an eastern species, and apparently has never been taken this far west before.

118. *Gomphus ventricosus* Walsh. Big Darby Creek, Harrisburg: 1♂ May 23, 1930, D. J. Borror.

119. *Cordulegaster diastatops* Selys. Cedar Swamp, Urbana: 14♂ June 12, 1926, and 1♀ June 7, 1927, J. S. Hine (OSM); 2♂ June 9, 1929, C. H. Kennedy (DZE); 2♂ and 1♀ June 6, 1931, 1♂ June 3, 1933, and 1♂ June 11, 1934, D. J. Borror. Eden Twp., Licking Co.: 1♂ July 6, 1931, M. D. Neiswander (OSM). Wakatomika Creek, Licking Co.: 1♂ May 21, 1932, and 1♀ May 30, 1934, D. J. Borror. Portage Co.: 1♂ July 7, 1935, J. A. Strasburg (in coll. D. J. Borror). This is an eastern species, but has been taken in Michigan and western Pennsylvania (Fraser, 1929), and in Indiana (Williamson, 1917, and Montgomery, 1930).

120. *Cordulegaster maculatus* Selys. Cantwell Cliffs, Hocking Co.: 1♂ June 14, 1925, C. H. Kennedy (DZE). Clear Creek, Hocking Co.: 1♀ June 17, 1931, J. S. Thomas (OSM); 1♂ and exuvium June 2, 1934, D. J. Borror.

121. *Somatochlora tenebrosa* Say. Byer, Jackson Co.: 2♀ July 1, 1934, C. F. Walker (OSM). Cedar Swamp, Urbana: 6♂ and 2♀ July 27, 1935, D. J. Borror. The specimens taken by Mr. Walker were two of several seen flying in a clearing near a small stream about a mile east of Byer. Those taken at Cedar Swamp were flying low over small pools in the open part of the swamp, and were fairly easy to capture.

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[1]The location of the specimens listed in this paper is indicated in parentheses following the name of the collector, e. g., DZE, the collection of the Department of Zoology and Entomology, Ohio State University; OSM, the collection of the Ohio State Museum. All specimens collected by the writer, except several duplicates of *Sympetrum ambiguum* which were sent to the Museum of Zoology at Ann Arbor, Michigan, are in the writer's collection.

Although this is only the second species of *Somatochlora* to be found in Ohio, it is probable that other species also occur here. Walker's distribution maps (Walker, 1925) suggest that *williamsoni* Walker and *linearis* Say may also occur in Ohio.

122. *Erythrodiplax umbrata* Linnaeus. Cedar Swamp, Urbana: 1♂ June 11, 1934, D. J. Borror. This is a very unusual record. *E. umbrata* is a neotropical species, ranging normally from northern Argentina to southern United States. The most northern records hitherto reported are Georgia (Hagen, 1861) and Woods Co., Oklahoma (Bird, 1932). This specimen was taken in a cedar bog, a relic of post-glacial times, certainly a type of habitat in which one would least expect to find a tropical species. The specimen is entirely black and fully adult; the wing-band is black and extends from the nodus to the middle of the stigma, as is the case with most of the specimens from Mexico and Central America. In specimens from South America the wing-band tends to be shorter, frequently not reaching the proximal end of the stigma. This specimen was taken in the same swing with a male of *Cordulegaster diastatops*.

It might be of interest to note in this connection that I have just received from Mr. B. Elwood Montgomery, of Lafayette, Indiana, two specimens of *E. umbrata* collected by him in southern Indiana: 1♂ Gibson Co., September 1, 1934, and 1♀ (heterochromatic) Pike Co., September 1, 1934. Both specimens are quite teneral, suggesting that this species has bred in southern Indiana during the past season.

123. *Erythrodiplax minuscula* Rambur. Lake Alma, Vinton Co.: 1♂, June 23, 1933, D. J. Borror. This is also a neotropical species, normally occurring from northern Argentina to southern United States. However, it has been taken in Indiana (Montgomery, 1930), Kentucky (Williamson, 1899), and Maryland (specimens in the Museum of Zoology, Ann Arbor, Michigan, collected by R. P. Currie). This specimen is similar to those from Florida which I have examined, but is slightly larger than Venezuelan specimens (hw. 20, abd. 17).

124. *Sympetrum ambiguum* Rambur. Middle Bass Island, Lake Erie: 1♂ August 4, 1933. Kelleys Island, Lake Erie: 26♂ and 3♀ August 26, 1933. Indian Lake, Logan Co.: 1♂ August 23, 1934, and 1♂ August 10, 1935. Minerva Lake, Franklin Co.: 1♂ August 3, 1935. Blacklick Woods, Franklin Co.: 1♂ August 16, 1935, W. R. Piper. Blacklick Woods, Fairfield Co.: 1♂ August 16, 1935. Black Lake, Logan Co.: 2♀ August 24, 1935. Lake Loramie, Shelby Co.: 9♂ and 1♀ August 24, 1935. All except the male from Blacklick Woods, Franklin Co., were collected by the writer. This species may be easily differentiated in the field from other species of *Sympetrum* by the conspicuous light green color of the face and the dark markings on the abdomen.

125. *Nehalennia gracilis* Morse. Cedar Swamp, Urbana: 1♂ June 6, 1931, D. J. Borror. Cranberry Bog, Buckeye Lake: 3♂ and 2♀ July 17, 1935, D. J. Borror.

126. *Enallagma boreale* Selys (=*E. calverti* Morse). Sandusky: 2♂ June 20, 1926, B. E. Montgomery (in coll. B. E. M.). Baum-

gardner's Lake, Franklin Co.: 1♂ May 14, 1930, and 1♂ May 24, 1930, D. J. Borror.

127. *Ischnura prognatha* Hagen. Crane Hollow, Hocking Co.: 1♂ April 20, 1930, C. H. Kennedy (DZE).

The 116 species of Odonata hitherto reported from Ohio, with the worker who first reported them (beginning with Kellicott, 1899) are as follows:

1. *Tachopteryx thoreyi* Hagen. Hine, 1925.
2. *Progomphus obscurus* Rambur. Hine, 1900.
3. *Hagenius brevistylus* Selys. Kellicott, 1899.
4. *Ophiogomphus rupinsulensis* Walsh. Kellicott, 1899.
5. *Erpetogomphus designatus* Hagen. Hine, 1913.
6. *Gomphus abbreviatus* Hagen. Hine, 1900.
7. *G. amnicola* Walsh. Hine, 1913.
8. *G. crassus* Hagen. Kellicott, 1899 (as *G. externus* Selys).
9. *G. dilatatus* Rambur. Kellicott, 1899.
10. *G. exilis* Selys. Kellicott, 1899.
11. *G. fraternus* Say. Kellicott, 1899.
12. *G. furcifer* Hagen. Kellicott, 1899.
13. *G. graslinellus* Walsh. Kellicott, 1899.
14. *G. lividus* Selys. Kellicott, 1899.
15. *G. notatus* Rambur. Kellicott, 1899.
16. *G. plagiatus* Selys. Kellicott, 1899.
17. *G. quadricolor* Walsh. Kellicott, 1899.
18. *G. spicatus* Hagen. Kellicott, 1899.
19. *G. spiniceps* Walsh. Kellicott, 1899.
20. *G. vastus* Walsh. Kellicott, 1899.
21. *G. villosipes* Selys. Kellicott, 1899.
22. *G. viridifrons* Hine. Hine, 1901.
23. *Dromogomphus spinosus* Selys. Kellicott, 1899.
24. *D. spoliatus* Hagen. Kellicott, 1899.
25. *Gomphaeschna furcillata* Say. Kellicott, 1899.
26. *Basiaeschna janata* Say. Kellicott, 1899.
27. *Boyeria grafiana* Williamson. Hine, 1913.
28. *B. vinosa* Say. Kellicott, 1899.
29. *Anax junius* Drury. Kellicott, 1899.
30. *A. longipes* Hagen. Kellicott, 1899.
31. *Nasiaeschna pentacantha* Rambur. Hine, 1900.
32. *Epiaeschna heros* Fabricius. Kellicott, 1899.
33. *Aeschna clepsydra* Say. Kellicott, 1899.
34. *A. constricta* Say. Kellicott, 1899.
35. *A. mutata* Hagen. Osburn and Hine, 1900 (as *A. verticalis* Hagen).
36. *A. umbrosa* Walker. Walker, 1912.
37. *A. verticalis* Hagen. Kellicott, 1899.
38. *Cordulegaster erroneus* Hagen. Kellicott, 1899.
39. *C. obliquus* Say. Kellicott, 1899.
40. *Macromia illinoiensis* Walsh. Kellicott, 1899.

41. *M. taeniolata* Rambur. Kellicott, 1899.
42. *Didymops transversa* Say. Kellicott, 1899.
43. *Neurocordulia obsoleta* Say. Hine, 1900.
44. *N. yamaskensis* Provancher. Hine, 1900.
45. *Epicordulia princeps* Hagen. Kellicott, 1899.
46. *Tetragoneuria cynosura* Say. Kellicott, 1899.
47. *Somatochlora hineana* Williamson. Williamson, 1931.
48. *Nannothemis bella* Uhler. Borror, 1930.
49. *Perithemis tenera* Say. Kellicott, 1899 (as *P. domitia* Drury).
50. *Celithemis elisa* Hagen. Kellicott, 1899.
51. *C. eponina* Drury. Kellicott, 1899.
52. *C. monomelaena* Williamson. Kellicott, 1899 (as C. *fasciata* Kirby).
53. *Ladona julia* Uhler. Kellicott, 1899 (as *Libellula exusta* Say).
54. *Libellula* (*Holotania*) *auripennis* Burmeister. Kellicott, 1899.
55. *L.* (*H.*) *cyanea* Fabricius. Kellicott, 1899.
56. *L.* (*H.*) *incesta* Hagen. Kellicott, 1899.
57. *L.* (*H.*) *luctuosa* Burmeister. Kellicott, 1899 (as *L. basalis* Say).
58. *L.* (*Neotetrum*) *pulchella* Drury. Kellicott, 1899.
59. *L.* (*Libellula*) *quadrimaculata* Linnaeus. Kellicott, 1899.
60. *L.* (*Eolibellula*) *semifasciata* Burmeister. Kellicott, 1899.
61. *L.* (*Holotania*) *vibrans* Fabricius. Kellicott, 1899.
62. *Plathemis lydia* Drury. Kellicott, 1899 (as *P. trimaculata* De Geer).
63. *Sympetrum corruptum* Hagen. Kellicott, 1899.
64. *S. obtrusum* Hagen. Kellicott, 1899.
65. *S. rubicundulum* Say (=*S. assimilatum* Uhler). Kellicott, 1899.
66. *S. semicinctum* Say. Kellicott, 1899.
67. *S. verum* Bartenef. Bartenef, 1915.
68. *S. vicinum* Hagen. Kellicott, 1899.
69. *Leucorrhinia intacta* Hagen. Kellicott, 1899.
70. *Pachydiplax longipennis* Burmeister. Kellicott, 1899.
71. *Erythemis simplicicollis* Say. Kellicott, 1899.
72. *Pantala flavescens* Fabricius. Kellicott, 1899.
73. *P. hymenaea* Say. Kellicott, 1899.
74. *Tramea carolina* Linnaeus. Kellicott, 1899.
75. *T. lacerata* Hagen. Kellicott, 1899.
76. *T. onusta* Hagen. Kellicott, 1899.
77. *Agrion aequabilis* Say. Kellicott, 1899.
78. *A. angustipennis* Selys. Hine, 1913.
79. *A. maculatum* Beauvais. Kellicott, 1899.
80. *Hetaerina americana* Fabricius. Kellicott, 1899.
81. *H. titia* Drury (=*H. tricolor* Burm.). Kellicott, 1899 (as *H. tricolor* Burm.).
82. *Archilestes grandis* Rambur. Williamson, 1930.
83. *Lestes congener* Hagen. Kellicott, 1899.
84. *L. disjunctus* Selys. Kellicott, 1899.
85. *L. eurinus* Say. Hine, 1900.
86. *L. forcipatus* Rambur. Kellicott, 1899.
87. *L. inaequalis* Walsh. Kellicott, 1899.

88. *L. rectangularis* Say. Kellicott, 1899.
89. *L. uncatus* Kirby. Kellicott, 1899.
90. *L. unguiculatus* Hagen. Kellicott, 1899.
91. *L. vigilax* Hagen. Kellicott, 1899.
92. *Argia apicalis* Say. Kellicott, 1899.
93. *A. bipunctulata* Hagen. Borror, 1930.
94. *A. moesta* Hagen. Kellicott, 1899.
95. *A. sedula* Hagen. Kellicott, 1899.
96. *A. tibialis* Rambur. Kellicott, 1899.
97. *A. violacea* Hagen. Kellicott, 1899.
98. *Amphiagrion saucium* Burmeister. Kellicott, 1899.
99. *Nehalennia irene* Hagen. Kellicott, 1899.
100. *Chromagrion conditum* Hagen. Kellicott, 1899.
101. *Enallagma antennatum* Say. Kellicott, 1899 (*as E. fischeri* Kellicott).
102. *E. aspersum* Hagen. Kellicott, 1899.
103. *E. carunculatum* Morse. Kellicott, 1899.
104. *E. civile* Hagen. Kellicott, 1899.
105. *E. divagans* Selys. Kellicott, 1899.
106. *E. doubledayi* Selys. Kellicott, 1899.
107. *E. ebrium* Hagen. Kellicott, 1899.
108. *E. exsulans* Hagen. Kellicott, 1899.
109. *E. geminatum* Hagen. Kellicott, 1899.
110. *E. hageni* Walsh. Kellicott, 1899.
111. *E. signatum* Hagen. Kellicott, 1899.
112. *E. traviatum* Selys. Kellicott, 1899.
113. *E. vesperum* Calvert. Kellicott, 1899 (as *E. pollutum* Hagen).
114. *Ischnura posita* Hagen. Kellicott, 1899.
115. *I. verticalis* Say. Kellicott, 1899.
116. *Anomalagrion hastatum* Say. Kellicott, 1899.

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Laboratory Geology

There has appeared another "Laboratory Manual for General Geology." The 31 exercises are distributed as follows: 2 on minerals, 3 on rocks, 12 on topographic maps, 6 on geologic maps, 2 on block diagrams, 1 on fossil plants, and 5 on fossil animals, all with explanations. The author has treated in a rather full manner the material covered in general Geology. The Manual is furnished with the necessary blank pages and tables for student use. There is also available with most exercises additional space entitled "Additional Questions and Instructor's Remarks," a most useful place for recording local geologic phases or conditions. The illustrations are good and the explanations and descriptive material well selected and clear. The manual does not follow any text or lectures although it would of course be best to follow a similar order of presentation in class and laboratory. All pages are scored for easy removal and punched for rebinding.

It is to be regretted that the author does not include, for locating points where he specifies topographic maps, an explanation of the Townships and Ranges printed on many of the United States topographic and geologic maps, although his method will work. An index to the exercises would not be amiss. However, it should prove a usable and convenient manual.—Willard Berry.

Laboratory Manual for General Geology (Physical and Historical), by Mark H. Secrist. xviii+295 pp.; 52 figs., 8 tables, 15 pls. New York, The Macmillan Co., 1935.

Fragmental Rocks

This useful book on fragmental rocks has just reached the reviewer's hands, although it was published in 1931. Professor Tickell, after a short introduction, considers size analysis, then porosity and permeability, the preparation of specimens, the identification of minerals, and the description of minerals found in sedimentary rocks. There are illustrations and tables to explain and supplement the text. It is not a book for those lacking fundamental scientific background, but in the right hands should prove very useful. Sources of methods other than geologic are drawn upon. Hence there are methods developed by hydrologists and ceramists along with geologic methods. The author states that the treatment is "practical rather than theoretical" and such it is. It is most certainly "The Examination of Fragmental Rocks." A bibliography of 108 titles is quite complete and gives sources of information more detailed than in the text. For all who are interested in the make-up of sedimentary rocks it should prove a boon. Petroleum geologists, soil geologists, and others will find it useful.

Willard Berry.

The Examination of Fragmental Rocks, by Frederick G. Tickell. x+128 pp., 51 figs., 18 tables. Stanford University Press, 1931.

STUDIES ON FRESHWATER BRYOZOA. III.

The Development of *Lophopodella carteri* var. *typica*

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INTRODUCTORY

As previously stated in Study I, *Lophopodella carteri* var. *typica* occurs in pond habitats on the under side of *Nymphaea* leaves and on *Vallisneria*, *Elodea*, *Potamogeton* and other pondweeds. It produces reproductive bodies known as statoblasts. These are of one type—free, annulated. They germinate and give rise to new colonies. Colonies of this form were collected at Squaw Harbor (Put-in-Bay) and East Harbor in the southwestern part of Lake Erie and taken into the laboratory. Their behavior under laboratory conditions was noted. Their released statoblasts were collected and in time germinated. The growth and development of the resultant colonies and their production of another crop of statoblasts was carefully noted and recorded. Since the observations were made on living material, no attempt will be made in the present study to discuss the histology of the various processes.

METHODS

In collecting, the colonies were either gently taken off the lily pads or lily stems with a scalpel blade or else the whole lily pad was brought into the laboratory and the colonies left undisturbed on it. They were kept in fresh lake water in fingerbowls. The water was changed daily to insure sufficient food supply and proper conditions for the polypides. As statoblasts were released by the colony they were put into a Syracuse watch glass (with water) until the time of germination. After germination, the watch glasses with the germinating statoblast or polypide were immersed in a finger bowl. This made possible microscopic study of the zooecia with the least disturbance.

Colonies which were collected during the summers of 1932 and 1933 were kept in the Stone Biological Laboratory—not

far from the collecting site—and later (in September) transferred to the laboratory at Ohio State University (Columbus, Ohio). Their behavior and development under laboratory conditions was studied until the succeeding summers. The animals were kept alive with at first daily, then twice weekly, changes of medium. The medium in which these animals were kept was simply greenhouse tank water and some organic debris from around the bases of aquatic plants which were grown in the greenhouse tanks. Some of the organisms which occurred in the water were Planaria, Ostracoda, Copepoda, Oligochaeta, Rotifera, Gastropoda and Protozoa, in addition to plant material.

OBSERVATIONS

Colonies of *L. carteri* were collected during the entire summer season. The earliest date for the finding of mature statoblasts was July 20 (1933). After that time they were found in almost every collection. However, in the 1932 collections (from Squaw Harbor) no mature statoblasts were recovered from the colonies until September 24 although developing statoblasts were found as early as August 19. The latest day for release of statoblasts in the laboratory from the comparatively small number of colonies of the 1932 collections was November 22. Statoblast germinations occurred from November 19, 1932, until the supply of statoblasts was exhausted (February 9, 1933). The succeeding year, germinations were continuous until the end of March, when observations were discontinued.

THE DEVELOPMENT OF A COLONY FROM A STATOBLAST

The dormant period of statoblasts has been given attention by relatively few workers—Braem, Brooks, Brown, Graupner, Kraepelin, Marcus, Oka and Wesenberg-Lund. These workers have given some very interesting observations on germination and dormancy of statoblasts of some of the following species: *Plumatella repens*, *P. coralloides*, *Cristatella*, *Fredericella*, *Pectinatella magnifica* and *Pectinatella gelatinosa*. Some workers insisted that freezing was necessary before the germination of statoblasts. Others believed that that was not necessary. The length of the rest period is also variously given. Brown (1933) has given a very good account of germinations under various conditions. Brooks (1929) concluded that *Pectinatella*

"statoblasts develop steadily from the time they are formed until the polypides are fully formed, just as buds do." This conclusion came as a result of observations upon the germination of statoblasts under different temperature and environmental conditions. A similar condition exists in *Lophopodella*, at least as concerns those statoblasts which developed in the laboratory. Statoblasts of *L. carteri* var. *typica* which were collected or which developed from the August 25, 1933, collection have hatched continually until the termination of observations—March 22, 1934, and there still remained a large number which might have hatched had they been permitted to develop to the proper stage.

The rest or dormant period of a statoblast is interpreted as the period between its release and its germination. Brown (1933) defined germination as the separation of the two valves and the protrusion of the polypide. Rest periods of *L. carteri* statoblasts varied from 34 to 137 days. The germination of these reproductive bodies was undoubtedly hastened by the subjection to laboratory temperature conditions. Figures for statoblasts under natural conditions of extremes of temperature would probably be considerably different.

GERMINATION

The first visible indication that a statoblast is ready to germinate is the splitting of the chitinous processes at the extremities of the valves and the appearance of crooked dark ridges on the capsule surface. The splitting is first noted at the tips of the processes. This continues to the base of the spines, then the valves also begin to split. The peculiar nature of the spined processes is clearly shown when they have split, for it is then that one notices that the barbs of the processes of one valve do not correspond to or coincide with the barbs of the corresponding processes on the other valve. This splitting process may take considerable time, more than a week, but just how much longer has not been determined.

After the valves have split to a slight degree, the embryo may be seen as a rounded ball or mass of tissues, grayish-white in color. The length of time which is required before this mass of tissues becomes a full-fledged polypide depends upon a great many factors such as the potentialities inherent within the statoblast, the nature of the medium in which the statoblast germinates, the temperature and other physical and biological

factors. Under unfavorable conditions, this mass of tissue never reaches the polypide stage but simply degenerates. For the past two years I have been unable to rear colonies from statoblasts which have hatched late in the year (November and December). However, those which germinated in January, February and March produced colonies. The failure in the first instance may have been due to improper care or to the fact that some of the statoblasts germinated prematurely and the polypides lacked sufficient vitality to carry them through the budding stages. However, this is merely supposition.

The time required before this ball of germinating tissue protrudes as a contractile and motile structure from between the valves is very short. It may be only a day or two, depending upon the factors previously mentioned. For want of a more descriptive term I shall use the term employed by Brooks—("mucous pad")—for this protruding structure. (Brooks used the term in connection with *Pectinatella*.) When this first appears, it can be divided into two distinct areas—an outer, clear whitish cellular rim and the remaining denser, grayish, more granular, inner portion. The distinction between these two areas is more marked in the early stages of the polypide than in the more advanced stages. This basal portion is very contractile and adhesive. If it is watched for a period of time, undulations, contractions or occasional movements may be observed. By this structure the polypide and the valves of the statoblast are attached more firmly to the substratum. This portion of the body wall may change its shape from an indefinite rounded mass to a finger-like projection or to a bi- or tri-lobate protrusion. It is very turgid, resembling a collodion sac filled with liquid.

As yet, the valves of the statoblast are quite close together. In the meantime the polypide is developing between the valves, hidden from view.

The polypide protrudes its tentacles beyond the edge of the valves in about two or sometimes three days after the "base" has appeared. The polypide is apparently well developed but still not fully grown. Its tentacles are much shorter than those of an adult. The same fact holds for the digestive tract. The distance from the lophophore to the invaginated fold is much smaller than in the adult. Even the number of tentacles may be fewer in the young than in the mature polypide.

If one observed the individual very closely and under proper illumination one can see the very delicate transparent ectocyst. It terminates at the invaginated fold. When the individual moves or contracts, the ectocyst is thrown up in a number of wrinkles or folds.

As the polypide continues to develop and enlarge, the valves of the statoblast are pushed farther and farther apart. The base begins to lose its distinctive appearance and gradually becomes more and more like the remainder of the polypide.

BUDDING

Brooks (1929) attempted to rear *Pectinatella* polypides, noting that they lived for two weeks upon yolk material and that they could be kept alive for six weeks but that they remained as single polypides instead of forming colonies. The trouble may have been with the food supply, because in the case of *Lophopodella*, as soon as the food supply was increased and the right kind of food used, the polypides began to multiply in number.

In the case of *Lophopodella* very complete records were kept of two colonies in particular, although a number of others were watched less closely. For convenience, we shall call these two colonies *A* and *B*. These colonies were all of the second generation, that is, were hatched from statoblasts which came from the colonies collected in Squaw Harbor.

Table I gives the number of individuals which were present in each colony at any particular time.

The interval between germination of a statoblast and the evagination of the second polypide is relatively long—19, 21, 38, and 43 days (figures for four colonies). The interval between the evagination of the second and third polypides was 8 days for Colony *A* and 3 days for Colony *B*. The intervals between the third and fourth polypides was 2 days for *A* and 3 days for *B;* between the fourth and fifth polypides, 4 days each for *A* and *B;* between the fifth and seventh polypides, 3 days for *A* and 1 day for *B;* between the seventh and eighth polypides, 1 day each for *A* and *B;* between the eighth and twenty-seventh polypides, 7 days for *A* and 8 for *B;* between germination and the thirty-seventh polypide of Colony *B* and between germination and the forty-fifth polypide of Colony *A* was 68 days and 70 days respectively.

TABLE I

Date	Rate of Budding		Statoblasts Released	
	Colony *A*	Colony *B*	Colony *A*	Colony *B*
	Number of individuals	Number of individuals		
I- 7-1933	Just hatched			
I- 9	1	Just hatched		
II-14	2	1		
II-21	2	2		
II-22	3	2		
II-24	4	3		
II-27	4 plus 3 buds	4		
II-28	5	4		
III- 1	5	4		
III- 3	7	5		
III- 4	8	7		
III- 5	12	8		
III- 6	13	9		
III- 7	15; statoblasts developing	10		
III- 8	20	14; statoblasts developing		
III- 9	24; about 9 statoblasts developing	16		
III-10	25	18		
III-11	27	22		
III-13	32; numerous statoblasts in colony; some with a dark brown central capsule	27		
III-14	40; colony distinctly tri-lobate	32; colony tri-lobate, one lobe showing signs of subdivision		
III-15	42; three main lobes in colony, each subdivided into two; about 24 developing statoblasts	33		
III-16	43; four main lobes	34		
III-17	44	34		
III-18	45; many statoblasts present in colony	37		
III-19	44; colony divides into two colonies; one polypide degenerated after the division	37; colony in five lobes, ready to divide	2	2
III-20		Colony divided in two		
III-21	One colony divided		1	1
III-22			1	
III-23		Another division		
III-24			3	
III-27			8	3
IV- 3			16	8
IV- 4			3	
IV- 6				1
IV-6 to V-25			6	1
V-31				1
VI-19	The *A* and *B* colonies, some of their statoblasts and some young colonies which had hatched between April 8 and June 18, 1933, from some of the statoblasts produced by Colonies *A* and *B* were transferred from the Zoology laboratory in Columbus, Ohio, to the Stone Biological Laboratory on Lake Erie.			
VI-20	The colonies did not survive the rough handling en route.			

Approximately 58 and 59 days elapsed between the germination of the statoblasts which produced Colonies *A* and *B* and the appearance of young, developing statoblasts in the two colonies. Exactly 40 days later (on the 89th day of the existence of Colony *B*) three statoblasts of Colony *B* germinated in the laboratory. The first statoblasts of Colony *A* to germinate did so when the colony was 110 days old. Of the 40 statoblasts produced by Colony *A*, 15 germinated between April 27 and June 18, 1933. Of the 17 produced by Colony *B*, 9 germinated between April 8 and May 15.

Although Colony *A* hatched two days before *B* and showed developing statoblasts earlier, these statoblasts did not begin to germinate until over three weeks after the first ones of Colony *B* had germinated. This is most likely a matter of individual variation.

The foregoing account has dealt principally with the asexual form of reproduction in this variety. Sexual reproduction needs careful study in order to make the life cycle story complete.

CONCLUSIONS

1. *Lophopodella carteri* var. *typica* was observed through two generations and to the beginning of the third, in the laboratory.

2. Careful accounts were kept of the development of two colonies in particular—the date of their germination, the time intervals between evagination of succeeding polypides and the rate of development, release and germination of statoblasts from these colonies.

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EXPLANATION OF PLATES

Plate I

Fig. 1. Two developing statoblasts in a colony of the August 29, 1932, collection.

Fig. 2. Side view of the statoblasts pictured in Fig. 1.

Fig. 3. The statoblasts in a slightly more advanced stage.

Fig. 4. A later stage in the development of a statoblast. The statoblast was drawn on October 17, 1932, and shows the lobate edges of the float. The edges had not as yet sufficiently differentiated to show the characteristic barbed processes. There were eight lobes on one side and nine on the other in this particular specimen.

Fig. 5. A still later stage in the development of a statoblast. This diagram shows a thin gelatinous covering or sac investing the statoblasts. Several statoblasts with such an investment were observed in late October in colonies of the September 25, 1932, collection. The processes at the ends are well differentiated.

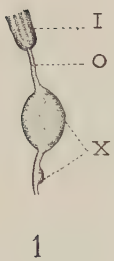
Fig. 6. A statoblast end bearing the barbed processes. The air cells of the float are also shown.

Fig. 7. A sketch of Colony *B* just preceding division. The statoblasts are shown as being somewhat concentrated in two lobes. To simplify the drawing, the polypides are roughly figured in the retracted state. The strip of coenoecial tissue connecting the three lobes becomes narrower and longer, due to the muscular activity of the polypide, particularly of the muscles of the body wall, until eventually, the connection breaks and the colony has divided into two parts.

Fig. 8. An enlarged view of the splitting of a barbed process at the extremity of the statoblast. The barbed process when superficially observed appears single but closer inspection shows that it is composed of two similar halves, one-half from each valve, and that the barbs of the halves do not necessarily coincide, but that there may be some overlapping.

ABBREVIATIONS

A—Ciliated tentacles.
B—Lophophore.
C—Tentacular crown.
D—Region of anal opening.
E—Rectum.
F—Esophagus.
G—Tentacular sheath.
H—Invaginated fold region. Musculature omitted.
I—Stomach.
J—Bud.
K—Retractor muscles.
L—Ectocyst.
M—Endocyst.
N—Body wall.
O—Funiculus.
P—Float.
Q—Capsule.
R—Barbed processes.
S—Statoblast valve.
T—Coenoecium.
U—Lobe.
V—Zooecium.
W—Epistome.
X—Statoblast.
Y—Temporary base or "mucous pad" (Brooks).
Z—Gelatinous covering.



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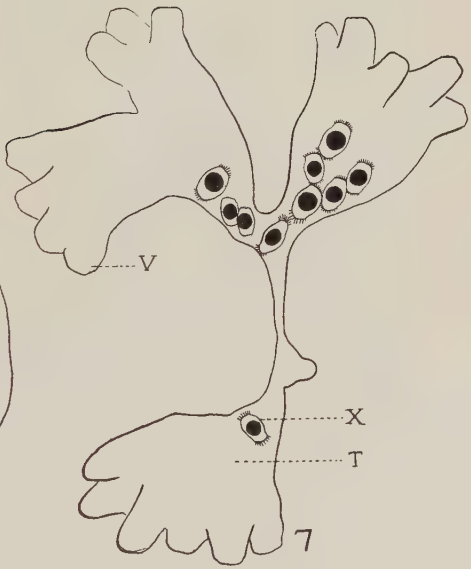

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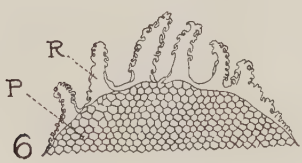

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EXPLANATION OF PLATES

Plate II

Fig. 1. Colony *B* three days after hatching (hatched on February 9, 1933). The basal part is contractile and motile; yolk granules present.

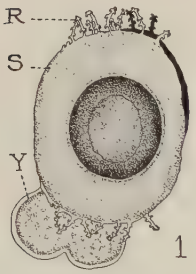
Fig. 2. Colony *B* as it appeared on February 13, showing the protruding tentacular crown of the first individual. When the surroundings were disturbed, the polypide quickly withdrew from sight between the two statoblast valves.

Fig. 3. Colony *B* on February 14. The tentacles numbered 52 in *B* and 56 in *A* at this time. This view of the tentacular crown shows the relative lengths of the tentacles on the arms of the lophophore and about the oral region at this particular stage. The epistome is evident although the mouth is not shown clearly. A number of features of the polypide are omitted in the figure, the purpose of the sketch being merely to show the growth of the colony.

Fig. 4. Colony *A* as it appeared on February 1, 1933. It was hatched on January 7. A developing bud is shown in the body wall. The statoblast valves remained attached to the polypide until February 18. Older zooecia differ from the young in having longer tentacles, a larger lophophore, a longer digestive tract and a greater length of polypide between the lophophore and the invaginated fold. The ectocyst is shown as the outer extremely delicate and transparent membrane.

Fig. 5. A small colony, showing the general arrangement of the zooechia. Not all polypides can be shown from any one angle of observation, hence, there are more polypides present in the colony than pictured. In this figure, the tentacular crowns have been cut away and the internal organs of the polypides have been omitted for the sake of clarity.

(See page 464 for Explanation of Abbreviations)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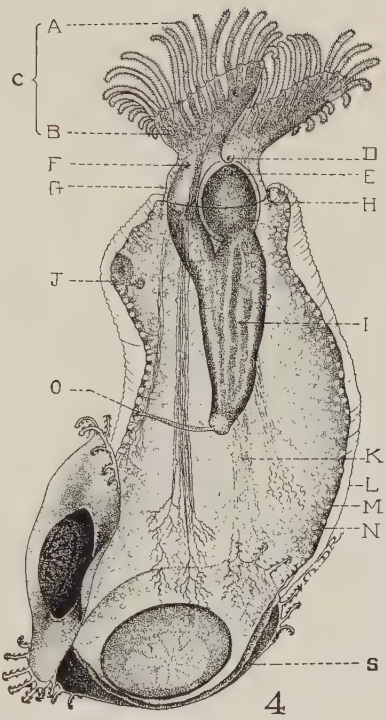
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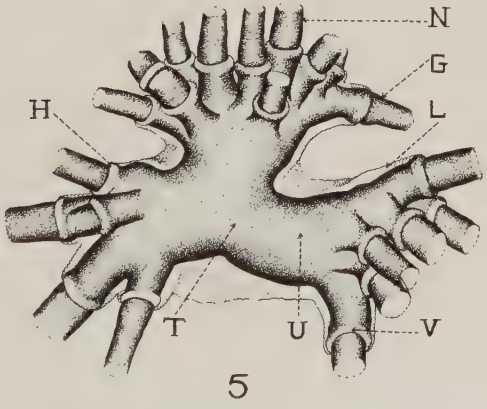
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BOOK NOTICES

Primate Evolution and Its Anatomical Evidence

Man's zoological position as a species is a question which always claims human interest. It will continue to be a source of speculation awaiting the day when his history recorded in fossil and artifact will have been fully disclosed.

"In order satisfactorily to study the specific problem of Man's phylogenetic origin, it is essential to visualize in proper perspective the evolutionary development of the whole group of Primates of which he is but one member."

Thus Professor Clark introduces a detailed description of the comparative anatomical and paleontological evidence which forms an essential basis of speculation on the phylogenesis of the Primates. Separate chapters are devoted to the evidence of the skull, the teeth, the limbs, the brain and special senses, the digestive, and the reproductive systems. Fossil material is described and compared with modern Primates. The author has brought together a great deal of knowledge of the anatomy of living Primates, much of which is the result of recent studies. The last chapter is a summary supplemented by useful charts showing the main morphological trends in the Lemuroidea, the Old and New World Tarsioidea and the Anthropoidea. Thus man is seen to comprise only one family in the large, divergent, and ancient order of Primates.

This book should prove invaluable to the Anatomist, the Anthropologist, and the General Zoologist as an authentic and comprehensive source book in its field.—JOHN W. PRICE.

Early Forerunners of Man, by W. E. LeGros Clark. xvi+296 pp. Baltimore, William Wood and Co., 1934.

Sahara

To most of us the term "desert" conotates something of Oriental mystery and strangeness; hence we should find much of interest in the recent translation by Dorothy F. Mayhew of E. F. Gautier's work, "Sahara, the Great Desert." Gautier explains the unique setting of the Sahara, which covers many more degrees of longitude than degrees of latitude, and has a peculiar climate which influences desert life. The geography and the geologic history since the close of the Tertiary is discussed. Here the influence of the "pre-desert" drainage on the present geographic organization on life is shown. Various regions are discussed in more detail to bring out the vivid difference between "normal" humid regions and the desert life. The influence of the Nile on the Sahara is clearly explained, it being the only river crossing this human barrier. The book is in reality a manual of geography and Quaternary geology for this great arid area which in the geologic past was not a dessicated region.

The volume is concise almost to the point of being abrupt, but for all that, is very readable and interesting. Of the 32 illustrations 6 are small maps or block diagrams showing various local details such as stream capture and the like. A map of the Sahara on the scale of about 220 miles to the inch, is folded in. This map shows sand dune areas and regions elevated 1,600 to 5,000 feet, 5,000 to 10,000 feet and over 10,000 feet, as well as tours, railways and wells (important in such dry regions).

This authorized English translation has incorporated in it much additional material which Professor Gautier has accumulated since the first appearance of "Le Sahara" in 1928. The Columbia University Press has given us a well-handled book, Miss Mayhew a fine translation, and Professor Gautier an interesting and valuable work on this great region.—WILLARD BERRY.

Sahara, the Great Desert, by E. F. Gautier (translated by Dorothy F. Mayhew). xviii+264 pp. New York, the Columbia University Press, 1935.

Principles of Insect Morphology

On rare occasions there appears in a given scientific field an outstanding masterful presentation of the subject matter in the form of a book. Recently a book of this character has appeared in the field of entomology, namely, "Principles of Insect Morphology," by R. E. Snodgrass, of the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine. An examination of the book soon reveals its outstanding features. It is an exhaustive compilation of the best literature on the subject and also includes a great deal of original information Without much doubt the publication will prove to be an excellent reference for entomologists, particularly for those conducting investigations on external or internal anatomy of insects.

One of the remarkable features of the book is the presence of numerous, clear-cut and beautifully labelled drawings. These add greatly to a clear understanding of the discussions. The book presents an introductory chapter, a concise chapter on embryology and development, nine chapters on external morphology, and eight chapters on internal morphology. At the ends of many chapters an excellent glossary of terms has been included. It is the personal opinion of the reviewer that a general glossary at the end of the book would have been more convenient.

All libraries possessing entomological literature and students and investigators in entomology should possess, or have access to, this excellent publication.

A. Peterson.

Principles of Insect Morphology, by R. E. Snodgrass. xix+667 pp. New York and London, McGraw-Hill Book Co., 1935.

Dynamical Meteorology

Professor Brunt divides his recent book into twenty chapters with a total of some 208 sections. The first chapter gives the facts which call for explanation. The second deals with certain statistical and thermal relationships. Chapter three deals with damp air, while four handles thermodynamics of the atmosphere. Radiation is considered in chapter five and radiation in the troposphere in the sixth. Radiative Equilibrium and the stratosphere are discussed in the seventh chapter. Chapters from eight on consider such subjects as general equations of motion, motion under balanced forces, surfaces of discontinuity, winds, turbulences, eddies, classification of winds, life-history of surface air currents, the polar front and cyclones, anticyclones, and general circulation. Some idea of the physical (and mathematical) side of the book can be gotten from the number of mathematical equations in the first 16 chapters, there being some 567 major ones.

This is not an elementary volume on meteorology but rather one for advanced students who have sufficient physical background to enter upon the theoretical field. The professional meteorologist will find much of interest here.

The 112 figures, ranging from autographic records to polar projections showing temperature and pressure, are carefully selected and very clear. Professor Brunt's style is direct, making for easy reading. As would be expected, the volume uses mostly British or European examples for small areas. It fills a place which, as far as I know, has not previously been filled in English-speaking countries.

Willard Berry.

Physical and Dynamical Meteorology, by David Brunt. xxii+411 pp. Cambridge, at the University Press. New York, The Macmillan Co., 1935.

Physics from Then until Now

This book gives to the layman a very graphic and fascinating account of the development in physical science from its beginning in pre-Greek times to the modern era. It can be recommended to readers who have only a small knowledge concerning this subject and is especially suitable as a text for introductory and survey courses for college students desiring to visualize what has been the purpose and scope of physical science.—H. H. Nielsen.

The Rise of Modern Physics, by Henry Crew. Second Edition, revised and enlarged. xix+434 pp. Baltimore, The Williams and Wilkins Co., 1935.

Pyrethrum

Beginning with a history of the production and manufacture of pyrethrum products this interesting discussion treats of the growing, cultivating, harvesting and marketing of the plant and its products. The insecticidal or active principle is then discussed and the methods used to evaluate the insecticidal value both chemically and biologically. The comparative value of various commercial grades of pyrethrum is discussed, the effect of storage, light and heat upon the reduction of the active principle and the manufacture and production of different types, grades and extracts. The latter portion deals entirely with the uses of pyrethrum as an insecticide in connection with various types of insects such as live stock, household, horticultural and other insect pests. This portion contains the results of the more important research work. An excellent bibliography containing some six hundred references is appended.

This is a valuable reference book for students who are interested in methods of insect control.—DWIGHT M. DELONG.

Pyrethrum Flowers, by C. B. Gnadinger. xi+269 pp. Minneapolis, McGill Lithograph Co., 1934.

Man and His Future

The British have pioneered in the field of popularizing science, and now the author of "The Mechanism of Creative Evolution" has joined the parade. This new little volume from his pen brings genetics to the general reader in most interesting and readable form. An intriguing opening chapter on the mystery of life is followed by the usual account of Mendel's work and the principles of heredity. Several chapters on genes and the gene complex give the author an opportunity to exercise his sense of the dramatic. The discussion of genes leads naturally into an account of evolutionary processes, past and present. This in turn opens the door to a discussion of possible trends in evolution in the future. Here the author gives his imagination full rein, and the ensuing speculations are thought-provoking, to say the least. The book can be read in an hour, and it will be an hour well spent.—L. H. S.

Heredity and the Ascent of Man, by C. C. Hurst. ix+136 pp. Cambridge, England, at the University Press. New York, the Macmillan Co., 1935.

Quantum Mechanics

This is a textbook especially useful for and adaptable to the needs of the experimental physicist. The mathematical prerequisites are kept to the absolute minimum, the requirements being only a working knowledge of calculus and differential equations. After an introduction to the principle of the quantum mechanics, it is applied to many important problems of especial interest to the chemist and physicist, the solution to the Schrödinger equations being carried out in scrupulous detail. Of especial value are the many tables and appendices found throughout and at the end of the book.—H. H. NIELSEN.

Introduction to Quantum Mechanics, by L. Paulding and E. B. Wilson, Jr. xiii+468 pp. New York, McGraw-Hill Book Co., 1935.

Oriental Scutelleroidea

One might judge from the title of this work that it would be a rather dry subject to review, but it is, in fact, much more than a faunal catalogue since the author discusses the faunal relations and derivations in such manner as to make it a distinct contribution to zoogeography. There is an introduction of nine pages discussing the sources of information and the general faunal areas, a catalogue occupying 168 pages, and annotated bibliography which is very complete and occupies seventy pages, the whole volume consisting of iv and 294 pages.

The distinctly interesting geographic section is included in his discussion of the faunal regions and these are given as (1) Indo-China which includes South China and Formosa, (2) Manchurian, including North China, Manchuria and Korea, (3) Indian, including India proper, (4) Ceylonese for the Island of Ceylon, (5) Malaysian, including Malay Peninsula and adjacent islands, (6) Philippine,

(7) Austro-Oriental, including most of the East Indian Archipelago, (8) Japanese, and (9) Siberian, including Mongolia, Tibet and Sinkiang. In discussing these inter-relationships of faunae Dr. Hoffman has been wisely conservative in the omission of any final conclusions or deductions, evidently appreciating the uncertainty of positive conclusions in a region where there has been so much opportunity for intermigration. Such a group of insects, however, is perhaps less affected by migrations than many other groups, but it would seem that there is a fair agreement with the faunal areas that have been indicated for such vertebrate groups as birds and mammals which, of course, have been much more thoroughly studied than the insects.

The work is a good example of typography, corresponding with the Journal of the Lingnan University of which this is a Science Bulletin. It is certainly a very commendable contribution to our knowledge of a little known region.

H. Osborn.

An Abridged Catalogue of Certain Scutelleroidea (Plataspidae, Scutelleridae, and Pentatomidae) of China, Chosen, Indo-China, and Taiwan, by William E. Hoffmann. iv+294 pp. Lingnan University, Canton, China, 1935.

Life Relations of Algae

This book attempts to present in as simple a fashion as possible the author's conception of an orderly arrangement of algological material about which "any desired course may be planned." After a chapter on the classification of algae "based on evolutionary development, with special reference to pigmentation and food reserves," the major portion of the book (some 400 pages) is given over to a systematic treatment of the Cyanophyceae (Myxophyceae), Rhodophyceae, Phaeophyceae, Chrysophyceae and Chlorophyceae, with complete description to genus. A novel feature is the inclusion of a number of life cycles and descriptions of plants other than algae presented as bases of comparison with those of algae.

The five major groups of marine algae are considered as radically different from each other especially in the matter of pigmentation. The course followed in their evolution represents a parallel development of types. The author believes that "the factor of illumination has been and is the primary force in determining the present distribution of marine algae." On this assumption the blue-green algae developed originally at a time of very weak light, known as the Cyanophycean period. As stronger and stronger rays of light penetrated to the earth there occurred the Rhodophycean period, the Phaeophycean period, the Chrysophycean period, and finally the Chlorophycean period. The first four periods arose in the archaeozoic era, and the last one in the proterozoic.

The last three chapters discuss in order "The Problem of Algal Control," "The Algal Food of Animals," and "Marine Algae, Our Richest Source of Vitamins: Algae as Food for Man."

As one might expect, knowing the author's long years of study of the algae of the Pacific, the point of view is that of a Marine Algologist. Teachers not proficient in Latin and Greek will welcome the careful attention paid to the etymology of generic terms. An appendix is devoted to the "Standardization of Method of Drawing Algae for Publication." The illustrations and diagrams in most cases are presented on a large scale. An extended bibliography and a good index complete the book.—L. H. Tiffany.

The Algae and Their Life Relations, by Josephine E. Tilden. xii+550 pp. Minneapolis, The University of Minnesota Press, 1935.

Physical Principles

A new and very useful textbook suitable for an introductory course in physics for college students. In its mathematics prerequisite the book is very modest, and in it is incorporated the desirable idea of introducing as early as possible important concepts from modern physics. In the last chapters especially, several of these topics are expanded upon in some detail. The book contains throughout many clarifying illustrations and a great many excellent problems are available for student use.—H. H. Nielsen.

College Physics, by Mendenhall, Eve and Keys. x+592 pp. Boston, D. C. Heath and Co., 1935.

Learning Physiological Principles

This is an excellent laboratory guide for the training of students in the drinciples of physiology. Emphasis is placed upon the critical evaluation of the results of experiments, the drawing of suitable inferences, and the application of the principles involved. The distinction between actual objective data and the principles and inferences accruing from such data is an important one, and the authors have been careful to observe the distinction and train the student to observe it. The book is well and thoroughly illustrated. Of especial value is the appendix, containing information on the preparation of materials, the methods of chemical procedure, and the dosages of drugs for various experimental purposes.

L. H. S.

Experimental Physiology, by Maurice B. Visscher and Paul W. Smith. 191 pp., 75 fig. Philadelphia, Lea and Febinger. 1935.

Minerals for the Beginner

Someone looking for a simple beginning book for those who are interested in minerals and who lack formal training will welcome this little volume. Dr. Hawkins tells what minerals are and how to find and collect them. He discusses the types one is likely to find in various kinds of quarries. Finally (and this takes up most of the book) he describes some 187 minerals. A short bibliography and an index close the book.

The book is not exhaustive and makes no pretense of being so. However, for beginners or those interested as amateurs it is a good introduction.

WILLARD BERRY.

The Book of Minerals, by Alfred C. Hawkins. xii+161 pp. New York, John Wiley & Sons, 1935.

King's Bay

On the west coast of Spitsbergen in latitude 790 N. is situated a region of very interesting geology and complicated structure. The desire for information on the area due to the presence of coal resulted in the excellently arranged, well written and careful study of the geology of the King's Bay region.

In the area are found, from the oldest to the youngest, the following sections: basal granites overlain by the Hecla Hoek series of Ordovician age or older, composed of limestones, dolomites, quartzites and mica shists, upwards of 6000 meters thick. Overlying these in angular unconformity are Devonian conglomerates, sandstones and shales of about 300 m., and in places by some 100 m. of lower Carboniferous beds. These last two are overlain unconformably with middle and upper Carboniferous (450 m.), littoral and marine limy beds, with a Cyathophyllum limestone at the top. Some 250 m. of chert and cherty beds above the Cyathophyllum limestone are referred to upper Carboniferous and Permo-Carboniferous. Above these is a 40 m. layer of glauconite, green sandstone. Overlying unconformably these series of older rocks are a series of shales and clays, the Bottom shales, some 50 m. thick, which are referred to the Cretaceous. Conformably above them are some 200 m. of conglomerates, sandstones, shales and coals of Paleocene and possibly Eocene age. The six workable coals occur in this series. It is estimated that the seams contain 16.2 million tons, of which 6.58 million are workable. The coal was discovered in 1610 by English whalers, production began in 1916 and continued to 1929 when a slump in prices and an accident caused a shut-down. The mines are now full of ice, but a watch is maintained on the properties. The structure is rather complicated; much of the folding is late Tertiary.

This is an excellent memoir, well written (in English) and well illustrated. It is a valuable contribution to the geology of high latitudes.—WILLARD BERRY.

Geology of the King's Bay Region, Spitsbergen, with special Reference to the Coal Deposits, by Anders K. Orvin. 195 pp. Skrifter om Svalbard og Ishavet, No. 57. Oslo, 1934.

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